CO2 Emissions of Food Production by Country

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Why we chose the data

In this analysis we will be comparing the CO_2 emission rates of countries based on categorized food product production. This analysis purpose is find correlations between selected features in our data including, the name of the country producing the most emissions, the food products whose productions most or least significant impact the rates of emission and if population plays factor into rates. This analysis will consist of an overview of the data evaluated, a point-by-point analysis of the food product categories and evaluating the predictive value of the data using a machine-learning model.

We chose this dataset because we were interested in whether we could identify causality of a specific type of product with a country's overall CO_2 emissions. Population can also have an effect on this, including the level of industrial development of the country. We didn't go too far down that path because that would have been a very complex program.

Investigative Query

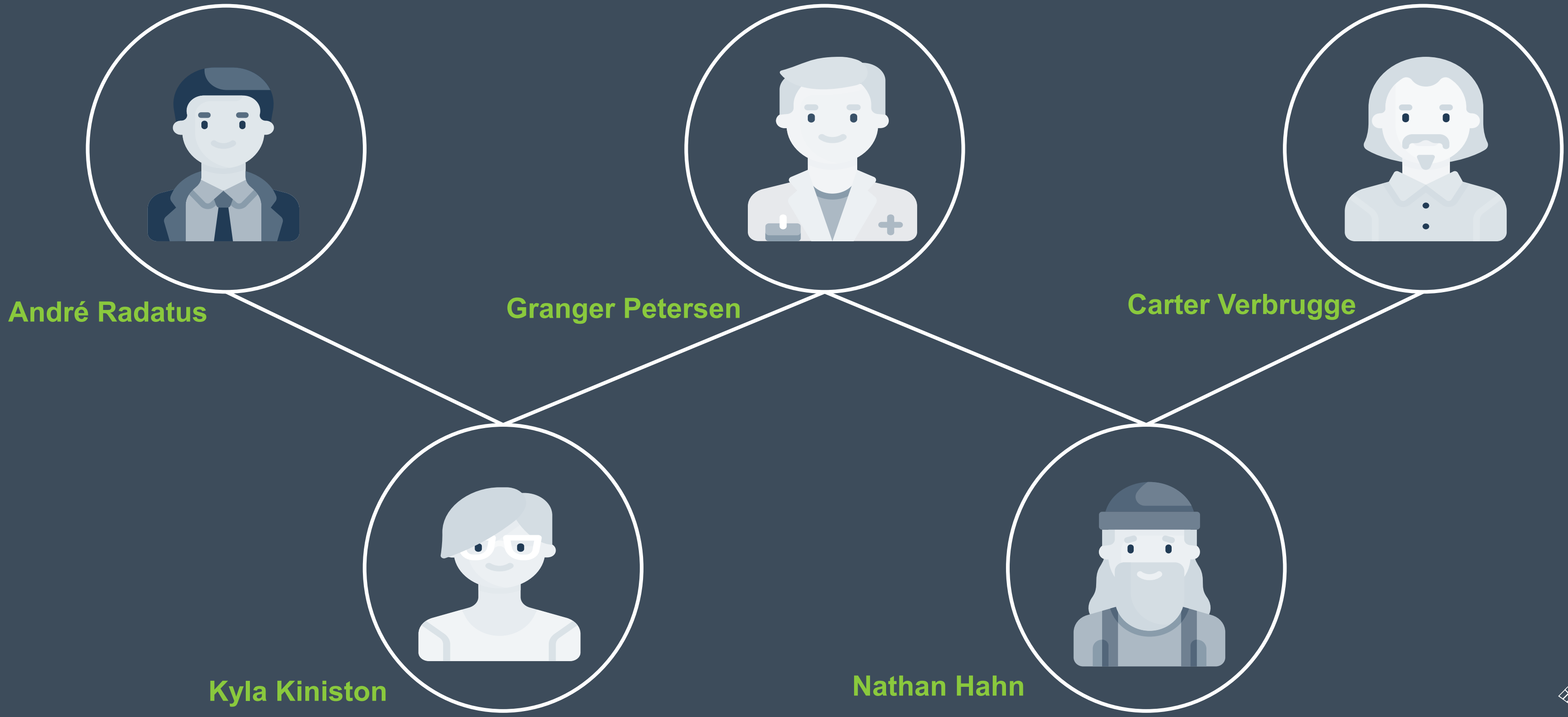
1. Does the amount of agricultural production predict the CO_2 emissions of a country?
2. What products being produced by countries have the highest and lowest CO_2 emissions?
3. Can we predict the year based on CO_2 emissions of a country?
4. Is there a correlation between population and the rate of production impacting CO_2 emissions?

220 Countries

43 Product Categories

Measuring CO_2 by kgs

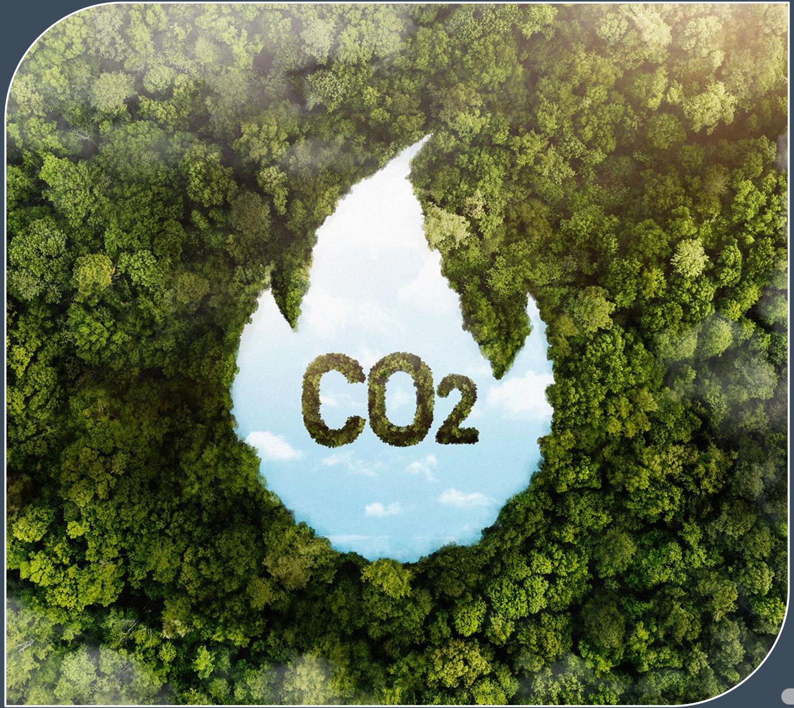
Our Team


André Radatus
Granger Petersen
Carter Verbrugge
Kyla Kiniston
Nathan Hahn

01

Introduction

A Picture of the Analysis



Shape of the Raw Data

CO_2 emissions by country and year

↓

~600,000 data points

Population by country and year

↓

~21,000 data points

Environmental Impact of Food Production

↓

~1,000 data points

Agricultural Production by country and year

↓

~8,400,000 data points

ETL

Extraction

Kaggle.com

-CO2 Emissions by countries by year

- Each entry (row) by country and year
- 1750 to 2020 was covered
- ~60,000 rows of data with 10 columns

-Agricultural production by country and year

- Each entry (row) by country, product, and Element (harvest/yield/production)
- 1961 to 2021 was covered
- ~80,000 rows of data with 105 columns

-Environmental impact of food production

- Each entry (row) by higher level edible agricultural product
- 43 high-level categories with 23 columns

World Bank

-Country Population by year

- Each entry (row) by country and year
- 2000 to 2021 was covered
- ~4200 rows with 5 columns

ETL

Transform

Goals
-Set reasonable boundaries on data
-Unify the data under common measurements and categories
-Create a flat file of all relevant data for the machine learning model

Known Issues to Resolve
-Inconsistency in defining countries due to political sensitivities
-Missing population of countries for some years (most commonly in overseas possessions)
-Food production was product specific while CO_2 production was at high-level categories
-New countries emerged in the time of interest and one country ceased to exist
-Data was missing for unknown reasons
-No pollution data on several products (notably farmed seafood and goat products)

Issues that Emerged
-'Production' data was discovered to be, to some extent, based on exports including re-exports (e.g. bananas from Poland)
-Some data was probably self-report leading to questionable data (China, North Korea)

ETL

Transform

Resolutions of Issues

-Data was restricted to the years 2000 to 2020
-Variables were dropped that were not specifically needed to address the questions
-Each country was considered unique for its time period and the data as a whole even if it emerged from another country
-Categorical data was collapsed as little as possible

- Overseas possessions and disputed territories were kept separate as much as possible
- Agricultural products were collapsed into high-level categories for CO_2 emissions

-The original source of population data was located and missing data was added
-The questionable data was treated as valid
-Missing data was treated as '0'
-Products with no CO_2 data were not used in the analyses

Methods

-A 'translation table' was created that allowed joining the food products with the food categories by identifying which products fit into respective categories
-Country code IDs were added to tables to reduce issues of naming differences
-Most data were transformed in Excel
-Joining occurred in a SQL database
-Aggregating occurred in Jupyter

Creating a Database

www.quickdatabasediagrams.com

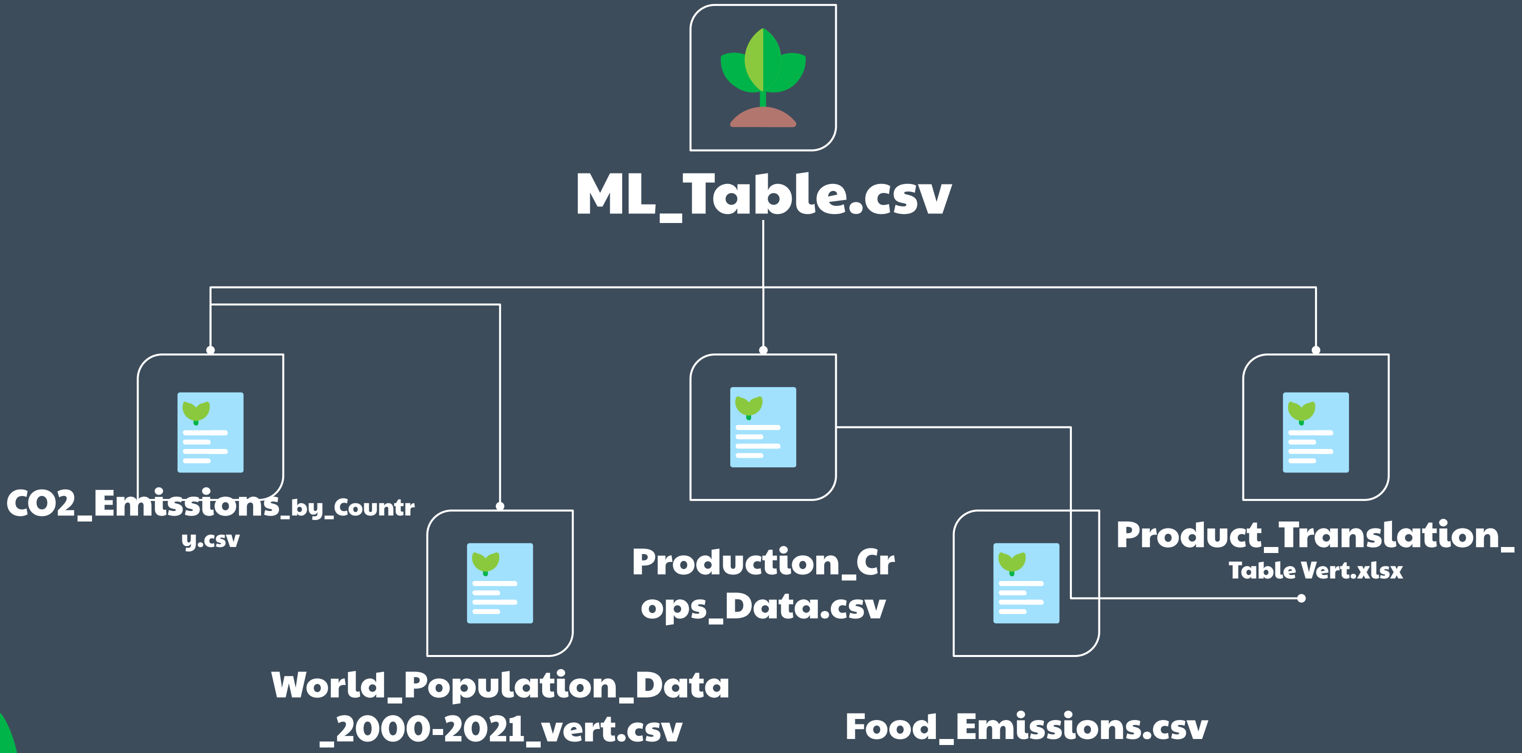
CO2_emission_by_countries	
Country	varchar
Code	varchar
Calling_Code	int
Year	int
CO2_emission_(Tons)	int
Population	(2022)-<
Area	int

World_Population_Data_2000-2021	
Country_Name	int
Country_Code	int
2000_[YR2000]	int
2001_[YR2001]	int
2002_[YR2002]	int
2003_[YR2003]	int
2004_[YR2004]	int
2005_[YR2005]	int
2006_[YR2006]	int
2007_[YR2007]	int
2008_[YR2008]	int
2009_[YR2009]	int
2010_[YR2010]	int
2011_[YR2011]	int
2012_[YR2012]	int
2013_[YR2013]	int
2014_[YR2014]	int
2015_[YR2015]	int
2016_[YR2016]	int
2017_[YR2017]	int
2018_[YR2018]	int
2019_[YR2019]	int
2020_[YR2020]	int
2021_[YR2021]	int

Production_Crops_Livestock_E_All_Data	
Area[country]	varchar
Item_Code_(CPC)	varchar
Item	varchar
Element_Code	int
Element	varchar
Unit	varchar
Y2000	int
Y2001	int
Y2002	int
Y2003	int
Y2004	int
Y2005	int
Y2006	int
Y2007	int
Y2008	int
Y2009	int
Y2010	int
Y2011	int
Y2012	int
Y2013	int
Y2014	int
Y2015	int
Y2016	int
Y2017	int
Y2018	int
Y2019	int
Y2020	int
Y2021	int

Food_emissions	
Food_product	int
Land_use_change	int
Animal_Feed	int
Farm	int
Processing	int
Transport	int
Packging	int
Retail	int
Total_emissions	int
Eutrophying_emissions_per_1000kcal_(gPOâ,„eq_per_1000kcal)	int
Eutrophying_emissions_per_kilogram_(gPOâ,„eq_per_kilogram)	int
Eutrophying_emissions_per_100g_protein_(gPOâ,„eq_per_100_grams_protein)	int
Freshwater_withdrawals_per_1000kcal_(liters_per_1000kcal)	int
Freshwater_withdrawals_per_100g_protein_(liters_per_100g_protein)	int
Freshwater_withdrawals_per_kilogram_(liters_per_kilogram)	int
Greenhouse_gas_emissions_per_1000kcal_(kgCOâ,,eq_per_1000kcal)	int
Greenhouse_gas_emissions_per_100g_protein_(kgCOâ,,eq_per_100g_protein)	int
Land_use_per_1000kcal_(mÂ²_per_1000kcal)	int
Land_use_per_kilogram	(mÂ²_per_kilogram)
Land_use_per_100g_protein_(mÂ²_per_100g_protein)	int
Scarcity-weighted_water_use_per_kilogram_(liters_per_kilogram)	int
Scarcity-weighted_water_use_per_100g_protein_(liters_per_100g_protein)	int
Scarcity-weighted_water_use_per_1000kcal_(liters_per_1000_kilocalories)	int

Plugging in the data



SQL Table Code

```
CREATE TABLE CO2_emission_by_countries (
 Country_Code int NOT Null,
 country varchar NOT NULL,
 Year_ET int NOT NULL,
 CO2_emissions_tonnes real NOT NULL
 PRIMARY KEY (Country_Code, Year_ET)
);
```

```
CREATE TABLE World_Pop_Data (
 Country_Code int NOT NULL,
 Country_Name varchar NOT NULL,
 Year_Pop int NOT NULL,
 Population real NOT NULL
 PRIMARY KEY (Country_Code, Year_Pop)
```

```
CREATE TABLE Production_Crops_Data (
 Country_Code int NOT Null,
 area varchar NOT NULL,
 Year_PC int NOT Null,
 item_code_PC real NOT NULL,
 item varchar NOT NULL,
 Unit varchar NOT NULL,
 Production real NOT NULL
 PRIMARY KEY ( PRIMARY KEY
(Country_Code, Year_PC, category_code)
);
```

```
CREATE TABLE Food_emissions (
 Category_Code int NOT NULL,
 Food_product varchar NOT NULL,
 land_use_change real NOT NULL,
 Animal_Feed real NOT NULL,
 Farm real NOT NULL,
 Processing real NOT NULL,
 Transport real NOT NULL,
 Packging real NOT NULL,
 Retail real NOT NULL,
 Total_emissions real NOT NULL,
 emissions_KGs_per_tonne real NOT NULL,
 PRIMARY KEY (category_code)
```

```sql
-- Create ML Table for machine learning model

CREATE TABLE ML_Table (
   country_code int NOT NULL, --PK
   area varchar NOT NULL,
   year_pc int NOT NULL, --PK
   CO2_emissions_tonnes real NOT NULL,
   Continent varchar NOT NULL,
   Population int NOT NULL,
--  39 categories of food production and their associated CO2 emissions
   category_code_1 int NOT NULL,
   food_product_categories_1 varchar NOT NULL,
   production_tonnes_1 real NOT NULL,
   total_kgs_CO2_1 real NOT NULL,
   category_code_2 int NOT NULL,
   food_product_categories_2 varchar NOT NULL,
   production_tonnes_2 real NOT NULL,
   total_kgs_CO2_2 real NOT NULL,
   category_code_3 int NOT NULL,
   food_product_categories_3 varchar NOT NULL,
   production_tonnes_3 real NOT NULL,
   total_kgs_CO2_3 real NOT NULL,
   category_code_4 int NOT NULL,
   food_product_categories_4 varchar NOT NULL,
   production_tonnes_4 real NOT NULL,
   total_kgs_CO2_4 real NOT NULL,
   category_code_6 int NOT NULL,
   food_product_categorie_6 varchar NOT NULL,
. . .
```

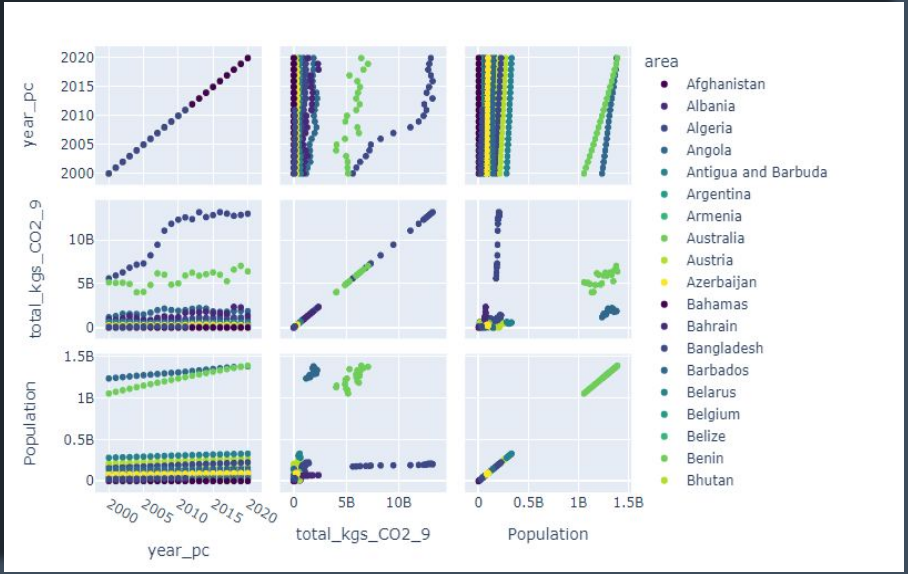
```sql
. . .
  food_product_categories_35 varchar NOT NULL,
   production_tonnes_35 real NOT NULL,
   total_kgs_CO2_35 real NOT NULL,
   category_code_37 int NOT NULL,
   food_product_categories_37 varchar NOT NULL,
   production_tonnes_37 real NOT NULL,
   total_kgs_CO2_37 real NOT NULL,
   category_code_39 int NOT NULL,
   food_product_categories_39 varchar NOT NULL,
   production_tonnes_39 real NOT NULL,
   total_kgs_CO2_39 real NOT NULL,
   category_code_40 int NOT NULL,
   food_product_categories_40 varchar NOT NULL,
   production_tonnes_40 real NOT NULL,
   total_kgs_CO2_40 real NOT NULL,
   category_code_41 int NOT NULL,
   food_product_categories_41 varchar NOT NULL,
   production_tonnes_41 real NOT NULL,
   total_kgs_CO2_41 real NOT NULL,
   category_code_42 int NOT NULL,
   food_product_categories_42 varchar NOT NULL,
   production_tonnes_42 real NOT NULL,
   total_kgs_CO2_42 real NOT NULL,
   category_code_43 int NOT NULL,
   food_product_categories_43 varchar NOT NULL,
   production_tonnes_43 real NOT NULL,
   total_kgs_CO2_43 real NOT NULL,
PRIMARY K
```

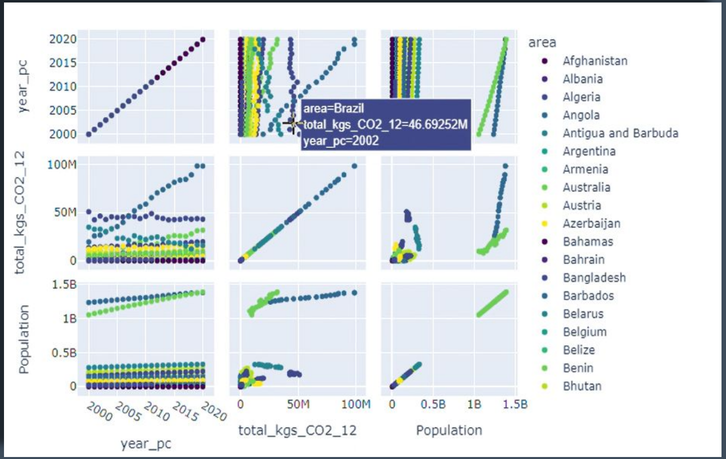
02

EDA

Exploratory Data Analysis

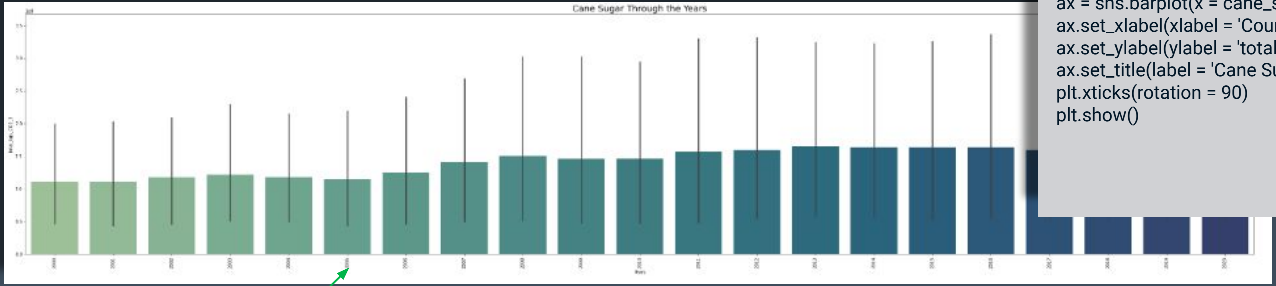
Dynamic Matrix based on Food Product





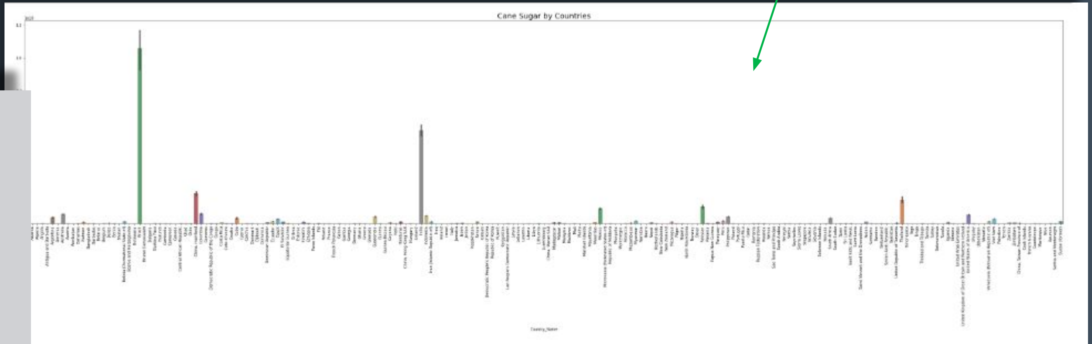

```
fig = px.scatter_matrix(cane_sugar, dimensions=["year_pc", "total_kgs_CO2_9", "Population"],
color="area", color_discrete_sequence =px.colors.sequential.Viridis)
fig.show()
```

Other Visual Tools Used in Breakdown



Cane_Sugar by Year

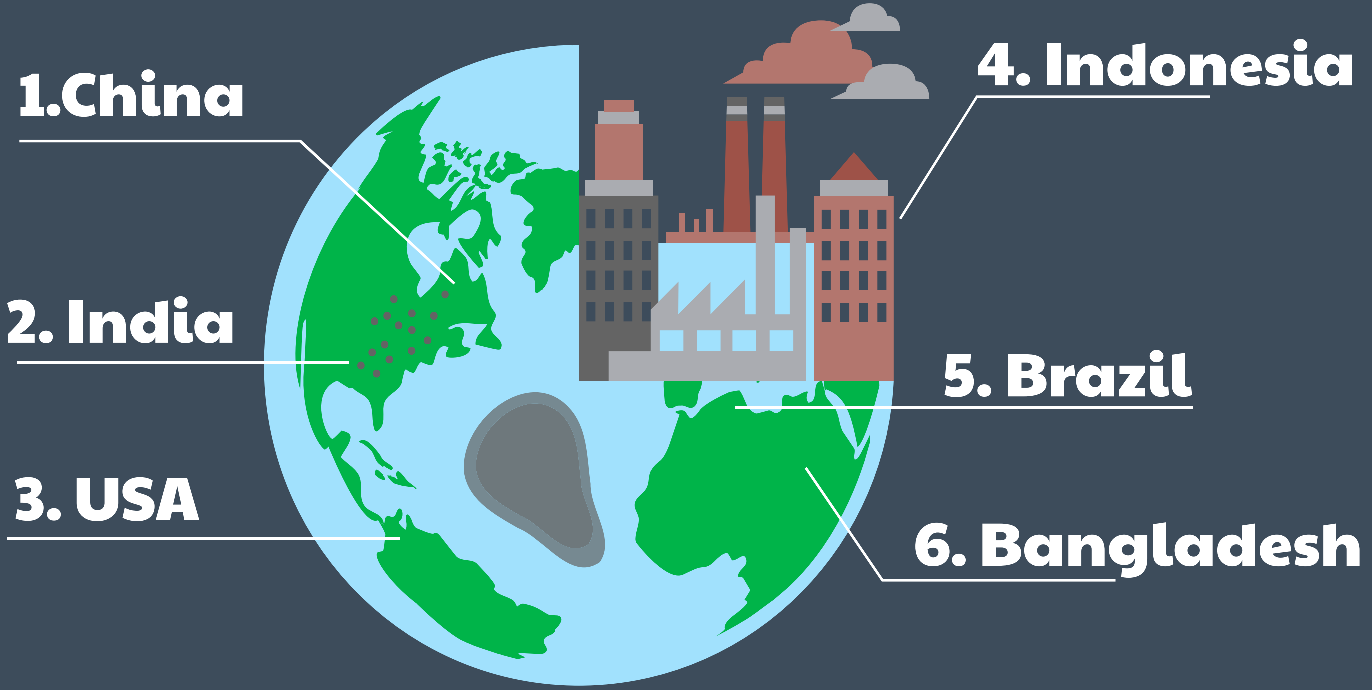
```
plt.rcParams['figure.figsize'] = (50, 10)
ax = sns.barplot(x = cane_sugar['area'], y = cane_sugar['total_kgs_CO2_9'], palette = 'deep')
ax.set_xlabel(xlabel = 'Country_Name', fontsize = 10)
ax.set_ylabel(ylabel = 'total_kgs_CO2_1', fontsize = 10)
ax.set_title(label = 'Cane Sugar by Countries', fontsize = 20)
plt.xticks(rotation = 90)
plt.show()
```



Cane_Sugar by Year

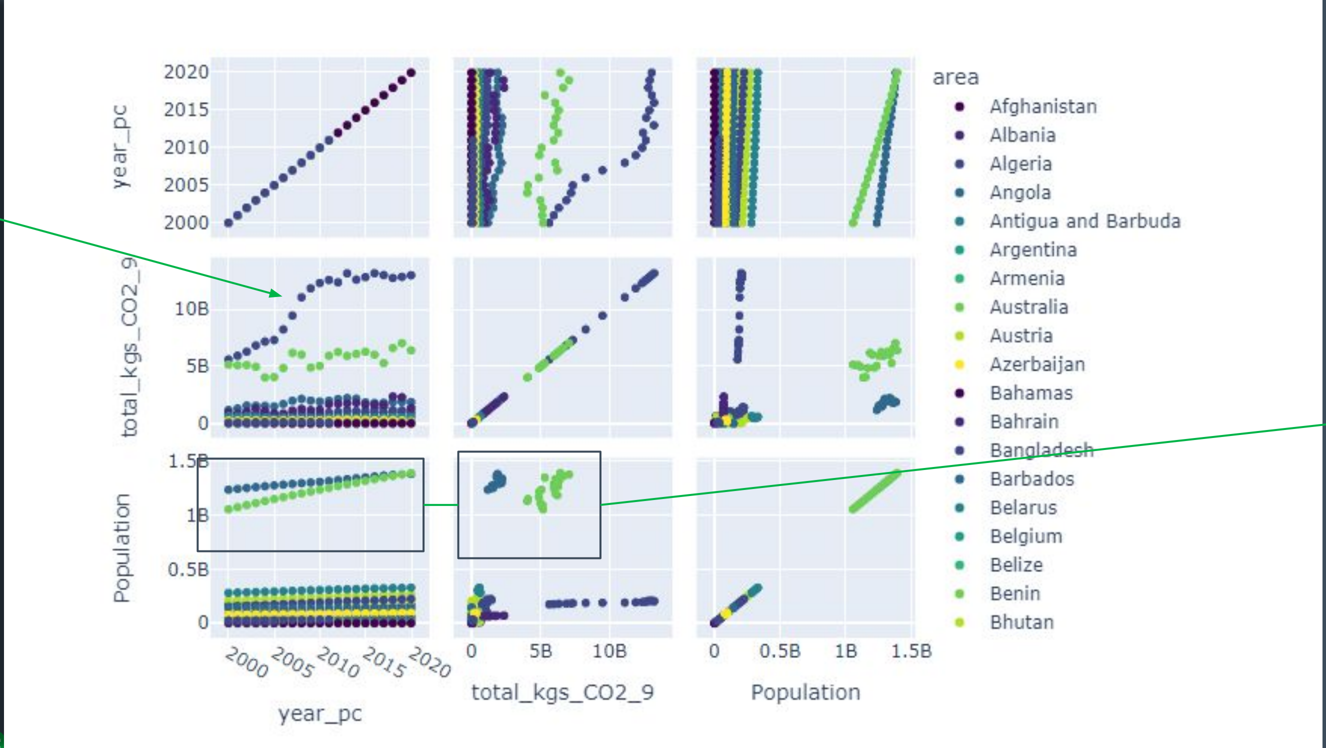
```
plt.rcParams['figure.figsize'] = (50, 10)
ax = sns.barplot(x = cane_sugar['year_pc'], y =
cane_sugar['total_kgs_CO2_9'], palette = 'crest')
ax.set_xlabel(xlabel = 'Years', fontsize = 10)
ax.set_ylabel(ylabel = 'total_kgs_CO2_9', fontsize = 10)
ax.set_title(label = 'Cane Sugar Through the Years', fontsize = 20)
plt.xticks(rotation = 90)
plt.show()
```

World Population



Matrix

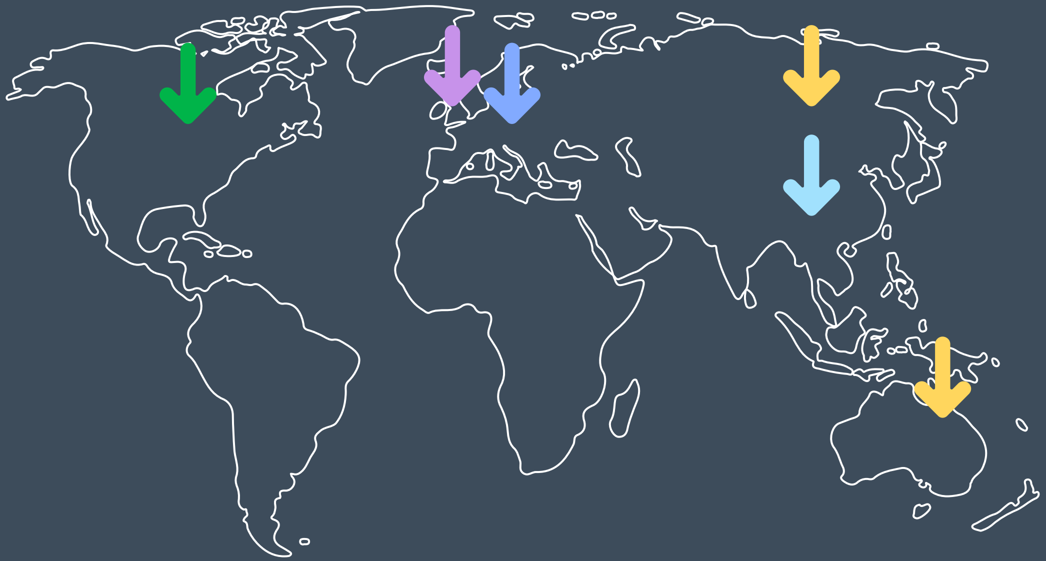
Brazil - 13.1B kgs CO2 produced from the production of cane sugar



Population
Country populations stay clustered according to normal population trends but have no direct correlation to amount of production emissions

China- Blue
India- Green

Countries with highest CO2 Production



Russia

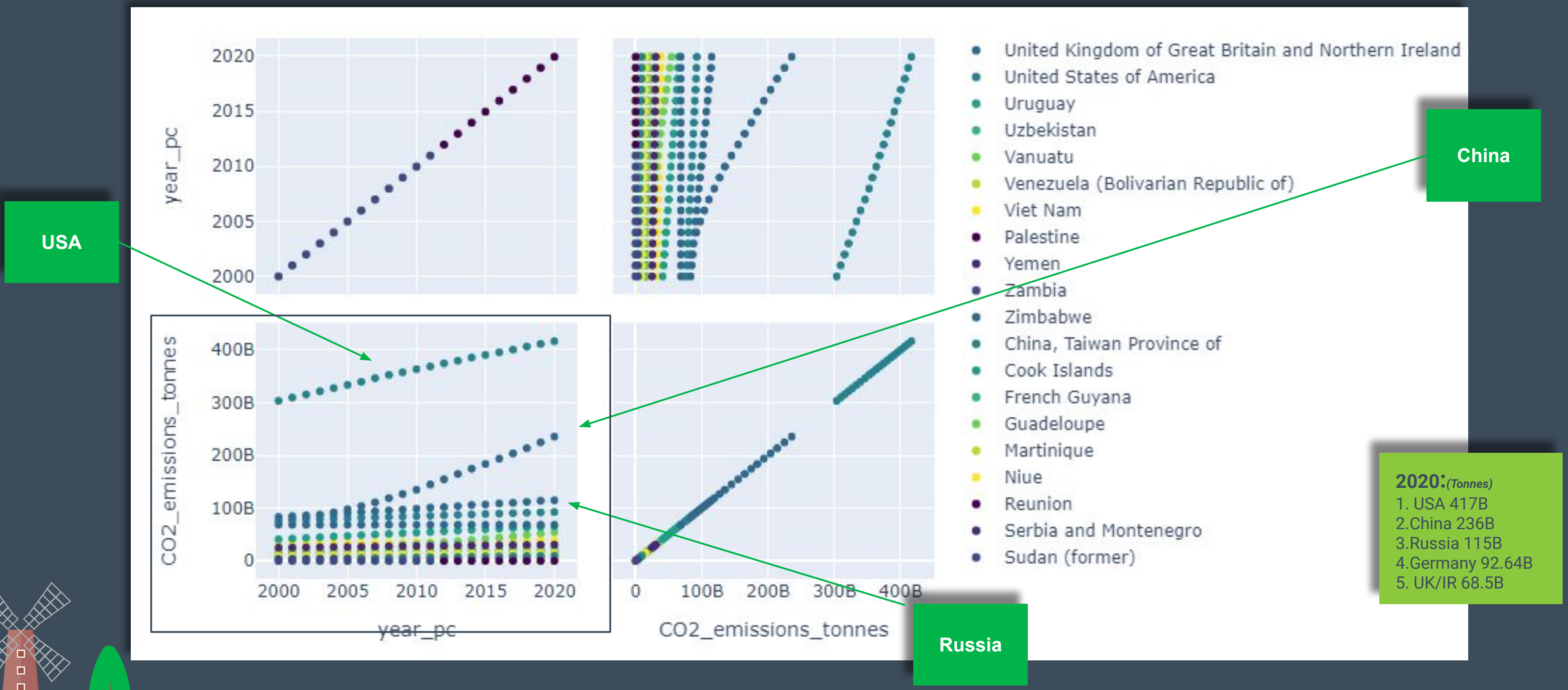
USA

Germany

China

UK/Northern Ireland

Matrix


year_pc
2020
2015
2010
2005
2000
CO2_emissions_tonnes
400B
300B
200B
100B
0
2000 2005 2010 2015 2020
year_pc
0 100B 200B 300B 400B
CO2_emissions_tonnes
United Kingdom of Great Britain and Northern Ireland
United States of America
Uruguay
Uzbekistan
Vanuatu
Venezuela (Bolivarian Republic of)
Viet Nam
Palestine
Yemen
Zambia
Zimbabwe
China, Taiwan Province of
Cook Islands
French Guyana
Guadeloupe
Martinique
Niue
Reunion
Serbia and Montenegro
Sudan (former)
USA
China
Russia
2020:(Tonnes)
1. USA 417B
2.China 236B
3.Russia 115B
4.Germany 92.64B
5. UK/IR 68.5B

03

Machine Learning

Comparing Models

Extra Trees Regressor

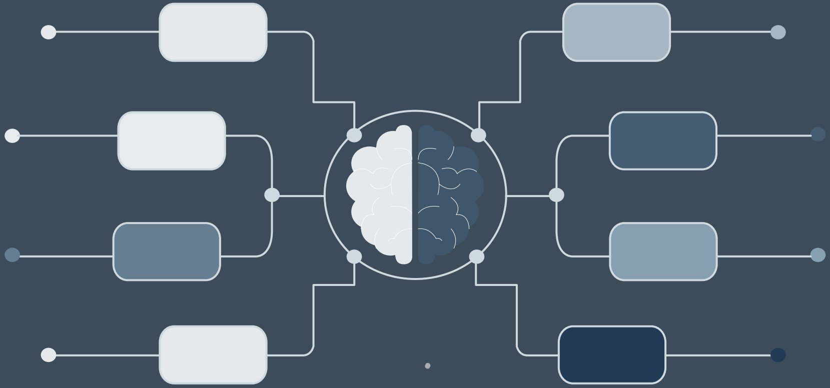
```
Mean Absolute Error: 335260395.91
Mean Squared Error: 2.560554705606461e+18
R-squared scores: 1.0
```

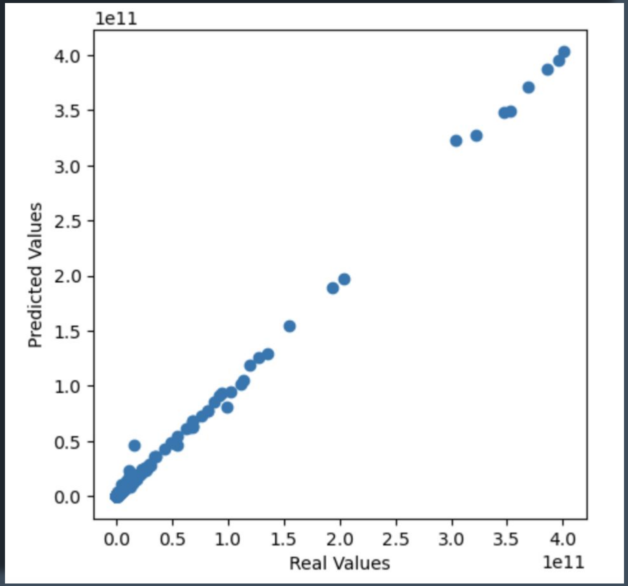
XG Boost Regressor

```
Mean Absolute Error: 973339725.21
Mean Squared Error: 1.545372475318290 4e+19
R-squared scores: 0.99
```

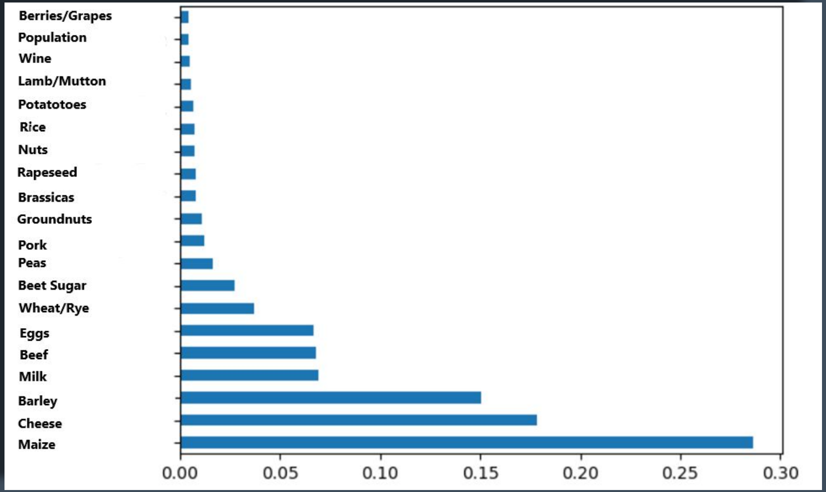
Random Forest Regressor

```
Mean Absolute Error: 441338770.84
Mean Squared Error: 9.226496706567215e+18
R-squared scores: 0.99
```



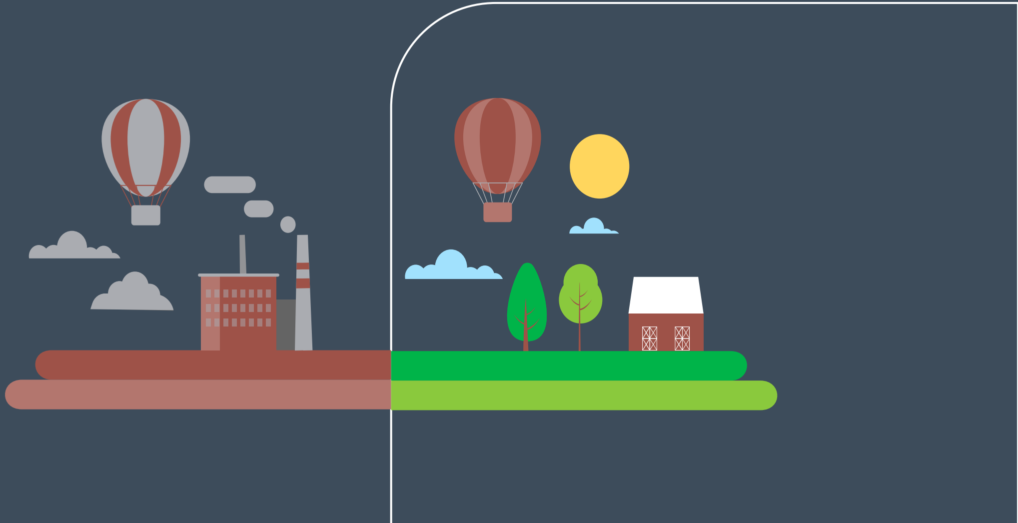


Tuning the Model



New Metrics

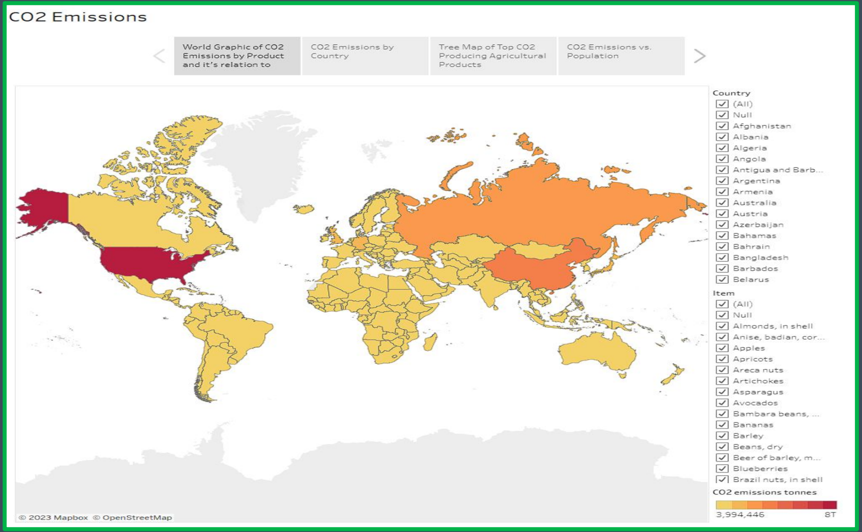
```
Mean Absolute Error: 287839779.42
Mean Squared Error: 1.527854974380916e+18
R-squared scores: 1.0
```



04

Findings

Tableau Dashboard



CO2 Emissions in the World

Food Products with highest CO2 Production

Maize(Corn)
18,467,107,546 Tonnes

Sugar Cane
34,684,911,578 Tonnes

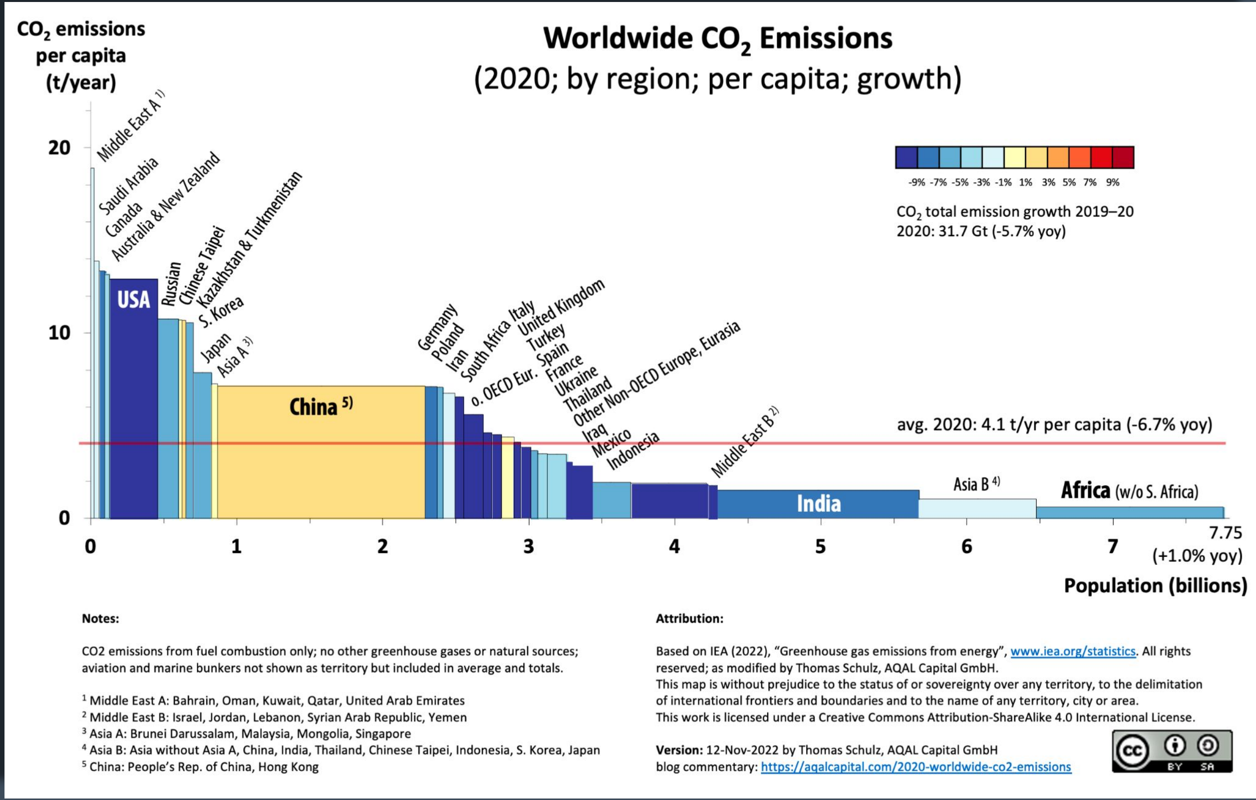
Rice
14,367,247,693 Tonnes

Wheat
14,130,705,994 Tonnes

27,630,468,397,999.0

The **BIG** number

Note for Future Analysis



Noteworthy further research directions should someone widen the scope of the project:

Study other greenhouse gases in the light of their effects on global warming.
Fun fact: methane—CH_4—is 20X more powerful than CO_2 in furthering global warming.
This has many implications for the rise in Earth's mean temperature, especially in the short term—accelerating us toward a "tipping point."
So why are we so interested in CO_2?
Because, even so, methane is only 25% of global warming.
CO_2 is 74%—almost 3X as much.

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Thank You !

Questions?

Resources

- Database 1 CO2 Emissions by Country | Kaggle
- Database 2 Environmental Impact of Food | Kaggle
- Database 3 Population | WorldBank
- Database 4 Emissions from Food | Environmental Impact of Food| Kaggle

```sql
-- Create ML Table for machine learning model

CREATE TABLE ML_Table (
    country_code int NOT NULL, --PK
    area varchar NOT NULL,
    year_pc int NOT NULL, --PK
    CO2_emissions_tonnes real NOT NULL,
    Continent varchar NOT NULL,
    Population int NOT NULL,
--  39 categories of food production and their associated CO2 emissions
    category_code_1 int NOT NULL,
    food_product_categories_1 varchar NOT NULL,
    production_tonnes_1 real NOT NULL,
    total_kgs_CO2_1 real NOT NULL,
    category_code_2 int NOT NULL,
    food_product_categories_2 varchar NOT NULL,
    production_tonnes_2 real NOT NULL,
    total_kgs_CO2_2 real NOT NULL,
    category_code_3 int NOT NULL,
    food_product_categories_3 varchar NOT NULL,
    production_tonnes_3 real NOT NULL,
    total_kgs_CO2_3 real NOT NULL,
    category_code_4 int NOT NULL,
    food_product_categories_4 varchar NOT NULL,
    production_tonnes_4 real NOT NULL,
    total_kgs_CO2_4 real NOT NULL,
    category_code_6 int NOT NULL,
    food_product_categorie_6 varchar NOT NULL,
    production_tonnes_6 real NOT NULL,
    total_kgs_CO2_6 real NOT NULL,
    category_code_7 int NOT NULL,
    food_product_categories_7 varchar NOT NULL,
    production_tonnes_7 real NOT NULL,
    total_kgs_CO2_7 real NOT NULL,
    category_code_8 int NOT NULL,
    food_product_categories_8 varchar NOT NULL,
    production_tonnes_8 real NOT NULL,
    total_kgs_CO2_8 real NOT NULL,
    category_code_9 int NOT NULL,
    food_product_categories_9 varchar NOT NULL,
    production_tonnes_9 real NOT NULL,
    total_kgs_CO2_9 real NOT NULL,
    category_code_10 int NOT NULL,
    food_product_categories_10 varchar NOT NULL,
    production_tonnes_10 real NOT NULL,
    total_kgs_CO2_10 real NOT NULL,
    category_code_11 int NOT NULL,
    food_product_categories_11 varchar NOT NULL,
    production_tonnes_11 real NOT NULL,
    total_kgs_CO2_11 real NOT NULL,
    category_code_12 int NOT NULL,
    food_product_categories_12 varchar NOT NULL,
    production_tonnes_12 real NOT NULL,
    total_kgs_CO2_12 real NOT NULL,
    category_code_13 int NOT NULL,
    food_product_categories_13 varchar NOT NULL,
    production_tonnes_13 real NOT NULL,
    total_kgs_CO2_13 real NOT NULL,
    category_code_14 int NOT NULL,
    food_product_categories_14 varchar NOT NULL,
    production_tonnes_14 real NOT NULL,
    total_kgs_CO2_14 real NOT NULL,
    category_code_15 int NOT NULL,
    food_product_categories_15 varchar NOT NULL,
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    total_kgs_CO2_15 real NOT NULL,
    category_code_17 int NOT NULL,
    food_product_categories_17 varchar NOT NULL,
    production_tonnes_17 real NOT NULL,
    total_kgs_CO2_17 real NOT NULL,
    category_code_18 int NOT NULL,
    food_product_categories_18 varchar NOT NULL,
    production_tonnes_18 real NOT NULL,
    total_kgs_CO2_18 real NOT NULL,
    category_code_19 int NOT NULL,
    food_product_categories_19 varchar NOT NULL,
    production_tonnes_19 real NOT NULL,
    total_kgs_CO2_19 real NOT NULL,
    category_code_20 int NOT NULL,
    food_product_categories_20 varchar NOT NULL,
    production_tonnes_20 real NOT NULL,
    total_kgs_CO2_20 real NOT NULL,
    category_code_21 int NOT NULL,
    food_product_categories_21 varchar NOT NULL,
    production_tonnes_21 real NOT NULL,
    total_kgs_CO2_21 real NOT NULL,
    category_code_22 int NOT NULL,
    food_product_categories_22 varchar NOT NULL,
    production_tonnes_22 real NOT NULL,
    total_kgs_CO2_22 real NOT NULL,
    category_code_23 int NOT NULL,
    food_product_categories_23 varchar NOT NULL,
    production_tonnes_23 real NOT NULL,
    total_kgs_CO2_23 real NOT NULL,
    category_code_24 int NOT NULL,
    food_product_categories_24 varchar NOT NULL,
    production_tonnes_24 real NOT NULL,
    total_kgs_CO2_24 real NOT NULL,
    category_code_25 int NOT NULL,
    food_product_categories_25 varchar NOT NULL,
    production_tonnes_25 real NOT NULL,
    total_kgs_CO2_25 real NOT NULL,
    category_code_26 int NOT NULL,
    food_product_categories_26 varchar NOT NULL,
    production_tonnes_26 real NOT NULL,
    total_kgs_CO2_26 real NOT NULL,
    category_code_27 int NOT NULL,
    food_product_categories_27 varchar NOT NULL,
    production_tonnes_27 real NOT NULL,
    total_kgs_CO2_27 real NOT NULL,
    category_code_28 int NOT NULL,
    food_product_categories_28 varchar NOT NULL,
    production_tonnes_28 real NOT NULL,
    total_kgs_CO2_28 real NOT NULL,
    category_code_29 int NOT NULL,
    food_product_categories_29 varchar NOT NULL,
    production_tonnes_29 real NOT NULL,
    total_kgs_CO2_29 real NOT NULL,
    category_code_30 int NOT NULL,
    food_product_categories_30 varchar NOT NULL,
    production_tonnes_30 real NOT NULL,
    total_kgs_CO2_30 real NOT NULL,
    category_code_31 int NOT NULL,
    food_product_categories_31 varchar NOT NULL,
    production_tonnes_31 real NOT NULL,
    total_kgs_CO2_31 real NOT NULL,
    category_code_32 int NOT NULL,
    food_product_categories_32 varchar NOT NULL,
    production_tonnes_32 real NOT NULL,
    total_kgs_CO2_32 real NOT NULL,
    category_code_33 int NOT NULL,
    food_product_categories_33 varchar NOT NULL,
    production_tonnes_33 real NOT NULL,
    total_kgs_CO_33 real NOT NULL,
    category_code_34 int NOT NULL,
    food_product_categories_34 varchar NOT NULL,
    production_tonnes_34 real NOT NULL,
    total_kgs_CO2_34 real NOT NULL,
    category_code_35 int NOT NULL,
    food_product_categories_35 varchar NOT NULL,
    production_tonnes_35 real NOT NULL,
    total_kgs_CO2_35 real NOT NULL,
    category_code_37 int NOT NULL,
    food_product_categories_37 varchar NOT NULL,
    production_tonnes_37 real NOT NULL,
    total_kgs_CO2_37 real NOT NULL,
    category_code_39 int NOT NULL,
    food_product_categories_39 varchar NOT NULL,
    production_tonnes_39 real NOT NULL,
    total_kgs_CO2_39 real NOT NULL,
    category_code_40 int NOT NULL,
    food_product_categories_40 varchar NOT NULL,
    production_tonnes_40 real NOT NULL,
    total_kgs_CO2_40 real NOT NULL,
    category_code_41 int NOT NULL,
    food_product_categories_41 varchar NOT NULL,
    production_tonnes_41 real NOT NULL,
    total_kgs_CO2_41 real NOT NULL,
    category_code_42 int NOT NULL,
    food_product_categories_42 varchar NOT NULL,
    production_tonnes_42 real NOT NULL,
    total_kgs_CO2_42 real NOT NULL,
    category_code_43 int NOT NULL,
    food_product_categories_43 varchar NOT NULL,
    production_tonnes_43 real NOT NULL,
    total_kgs_CO2_43 real NOT NULL,
PRIMARY KEY (country_code, year_pc)
);
```