DSBDA MINI PROJECT

Ananlysis and visualization of global CO2 emissions

```
from google.colab import drive
drive.mount('/content/drive')
```

```
Drive already mounted at /content/drive; to attempt to forcibly remount, call drive.mount("/content/drive", force_remount=True).
```

```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
%matplotlib inline
```

DATA PREPROCESSING

```
try:
    df = pd.read_csv("/content/drive/MyDrive/Colab Notebooks/DSBDA/CO2 emission by countries.csv", encoding='utf-8')
except UnicodeDecodeError:
    try:
        df = pd.read_csv("/content/drive/MyDrive/Colab Notebooks/DSBDA/CO2 emission by countries.csv", encoding='latin1')
    except UnicodeDecodeError:
        df = pd.read_csv("/content/drive/MyDrive/Colab Notebooks/DSBDA/CO2 emission by countries.csv", encoding='ISO-8859-1')
```

```
df.head()
```

	Country	Code	Calling Code	Year	CO2 emission (Tons)	Population(2022)	Area	% of World	Density(km2)
0	Afghanistan	AF	93	1750	0.0	41128771.0	652230.0	0.40%	63/km²
1	Afghanistan	AF	93	1751	0.0	41128771.0	652230.0	0.40%	63/km²
2	Afghanistan	AF	93	1752	0.0	41128771.0	652230.0	0.40%	63/km²
3	Afghanistan	AF	93	1753	0.0	41128771.0	652230.0	0.40%	63/km²
4	Afghanistan	AF	93	1754	0.0	41128771.0	652230.0	0.40%	63/km²

```
missing_values = df.isnull().sum()
print("Missing values:\n", missing_values)
```

```
Missing values:
 Country                 0
Code                  2168
Calling Code          3523
Year                     0
CO2 emission (Tons)      0
Population(2022)      6504
Area                  4336
% of World            4336
Density(km2)          6504
dtype: int64
```

```
print("Data types:\n", df.dtypes)
```

```
Data types:
 Country                object
Code                    object
Calling Code            object
Year                     int64
CO2 emission (Tons)    float64
Population(2022)       float64
Area                   float64
% of World              object
Density(km2)            object
dtype: object
```

```
print("Summary statistics:\n", df.describe())
```

```
Summary statistics:
                Year  CO2 emission (Tons)  Population(2022)          Area
count  59620.000000         5.962000e+04      5.311600e+04  5.528400e+04
mean    1885.000000         1.034774e+09      3.992260e+07  6.522073e+05
std       78.231085         1.041652e+10      1.482365e+08  1.865483e+06
min     1750.000000         0.000000e+00      1.131200e+04  2.100000e+01
25%     1817.000000         0.000000e+00      1.770414e+06  1.770450e+04
50%     1885.000000         0.000000e+00      8.673095e+06  1.103815e+05
75%     1953.000000         8.715092e+06      2.862920e+07  4.925730e+05
max     2020.000000         4.170000e+11      1.425887e+09  1.709824e+07
```

```
df.isnull().sum()
```

```
Country                   0
Code                   2168
Calling Code           3523
Year                      0
CO2 emission (Tons)       0
Population(2022)       6504
Area                   4336
```

```
% of World             4336
Density(km2)           6504
dtype: int64
```

```
df.shape
```

```
(59620, 9)
```

```
# Drop rows with missing values
df.dropna(inplace=True)
```

```
df.isnull().sum()
```

```
Country                0
Code                   0
Calling Code           0
Year                   0
CO2 emission (Tons)    0
Population(2022)       0
Area                   0
% of World             0
Density(km2)           0
dtype: int64
```

```
df.describe()
```

	Year	CO2 emission (Tons)	Population(2022)	Area
count	48509.000000	4.850900e+04	4.850900e+04	4.850900e+04
mean	1885.000000	1.160748e+09	4.186199e+07	6.328071e+05
std	78.231235	1.125903e+10	1.545682e+08	1.551563e+06
min	1750.000000	0.000000e+00	1.131200e+04	2.100000e+01
25%	1817.000000	0.000000e+00	2.305825e+06	2.633800e+04
50%	1885.000000	0.000000e+00	9.038309e+06	1.303730e+05
75%	1953.000000	1.660158e+07	3.054758e+07	5.516950e+05
max	2020.000000	4.170000e+11	1.425887e+09	9.984670e+06

```
df.shape
```

```
(48509, 9)
```

```
#Fill the Null values
df['Population(2022)'].fillna(df['Population(2022)'].mean(), inplace=True)
df['Area'].fillna(df['Area'].mean(), inplace=True)
```

LABEL ENCODING & DATA TRANSFORMATION

```
# Select columns of a specific data type
numeric_columns = df.select_dtypes(include=['float64', 'int64'])
categorical_columns = df.select_dtypes(include=['object'])
```

```
numeric_columns
```

	Year	CO2 emission (Tons)	Population(2022)	Area
0	1750	0.0	41128771.0	652230.0
1	1751	0.0	41128771.0	652230.0
2	1752	0.0	41128771.0	652230.0
3	1753	0.0	41128771.0	652230.0
4	1754	0.0	41128771.0	652230.0
...	...	...	...	...
59615	2016	736467042.0	16320537.0	390757.0
59616	2017	746048675.0	16320537.0	390757.0
59617	2018	757903042.0	16320537.0	390757.0
59618	2019	768852126.0	16320537.0	390757.0
59619	2020	779383468.0	16320537.0	390757.0

48509 rows × 4 columns

```
categorical_columns
```

	Country	Code	Calling Code	% of World	Density(km2)
0	Afghanistan	AF	93	0.40%	63/km²
1	Afghanistan	AF	93	0.40%	63/km²
2	Afghanistan	AF	93	0.40%	63/km²
3	Afghanistan	AF	93	0.40%	63/km²
4	Afghanistan	AF	93	0.40%	63/km²
...	...	...	...	...	...
59615	Zimbabwe	ZW	263	0.30%	42/km²
59616	Zimbabwe	ZW	263	0.30%	42/km²
59617	Zimbabwe	ZW	263	0.30%	42/km²
59618	Zimbabwe	ZW	263	0.30%	42/km²
59619	Zimbabwe	ZW	263	0.30%	42/km²

48509 rows × 5 columns

```
1 from sklearn.preprocessing import LabelEncoder
```

```
1 label_encoder = LabelEncoder()
```

```
1 df['Country_Encoded'] = label_encoder.fit_transform(df['Country'])
```

```
1 df.head()
```

	Country	Code	Calling Code	Year	CO2 emission (Tons)	Population(2022)	Area	% of World	Density(km2)	Country_Encoded
0	Afghanistan	AF	93	1750	0.0	41128771.0	652230.0	0.40%	63/km²	0
1	Afghanistan	AF	93	1751	0.0	41128771.0	652230.0	0.40%	63/km²	0
2	Afghanistan	AF	93	1752	0.0	41128771.0	652230.0	0.40%	63/km²	0
3	Afghanistan	AF	93	1753	0.0	41128771.0	652230.0	0.40%	63/km²	0
4	Afghanistan	AF	93	1754	0.0	41128771.0	652230.0	0.40%	63/km²	0

```
1 unique_sum = df['Country'].nunique()
2 print("Sum of unique values in 'Country' column:", unique_sum)
```

```
Sum of unique values in 'Country' column: 179
```

```
1 # Drop the 'Code' column from the DataFrame
2 df.drop(columns=['Code'], inplace=True)
```

```
1 df.head()
```

	Country	Calling Code	Year	CO2 emission (Tons)	Population(2022)	Area	% of World	Density(km2)	Country_Encoded
0	Afghanistan	93	1750	0.0	41128771.0	652230.0	0.40%	63/km²	0
1	Afghanistan	93	1751	0.0	41128771.0	652230.0	0.40%	63/km²	0
2	Afghanistan	93	1752	0.0	41128771.0	652230.0	0.40%	63/km²	0
3	Afghanistan	93	1753	0.0	41128771.0	652230.0	0.40%	63/km²	0
4	Afghanistan	93	1754	0.0	41128771.0	652230.0	0.40%	63/km²	0

```
1 df['Calling Code'] = pd.to_numeric(df['Calling Code'], errors='coerce')
2 df['% of World'] = pd.to_numeric(df['% of World'].str.rstrip('%'), errors='coerce')
3 df['Density(km2)'] = pd.to_numeric(df['Density(km2)'].str.replace('/km²', ''), errors='coerce')
```

```
1 df.head()
```

	Country	Calling Code	Year	CO2 emission (Tons)	Population(2022)	Area	% of World	Density(km2)	Country_Encoded
0	Afghanistan	93.0	1750	0.0	41128771.0	652230.0	0.4	63.0	0
1	Afghanistan	93.0	1751	0.0	41128771.0	652230.0	0.4	63.0	0
2	Afghanistan	93.0	1752	0.0	41128771.0	652230.0	0.4	63.0	0
3	Afghanistan	93.0	1753	0.0	41128771.0	652230.0	0.4	63.0	0
4	Afghanistan	93.0	1754	0.0	41128771.0	652230.0	0.4	63.0	0

```
1 df.dtypes
```

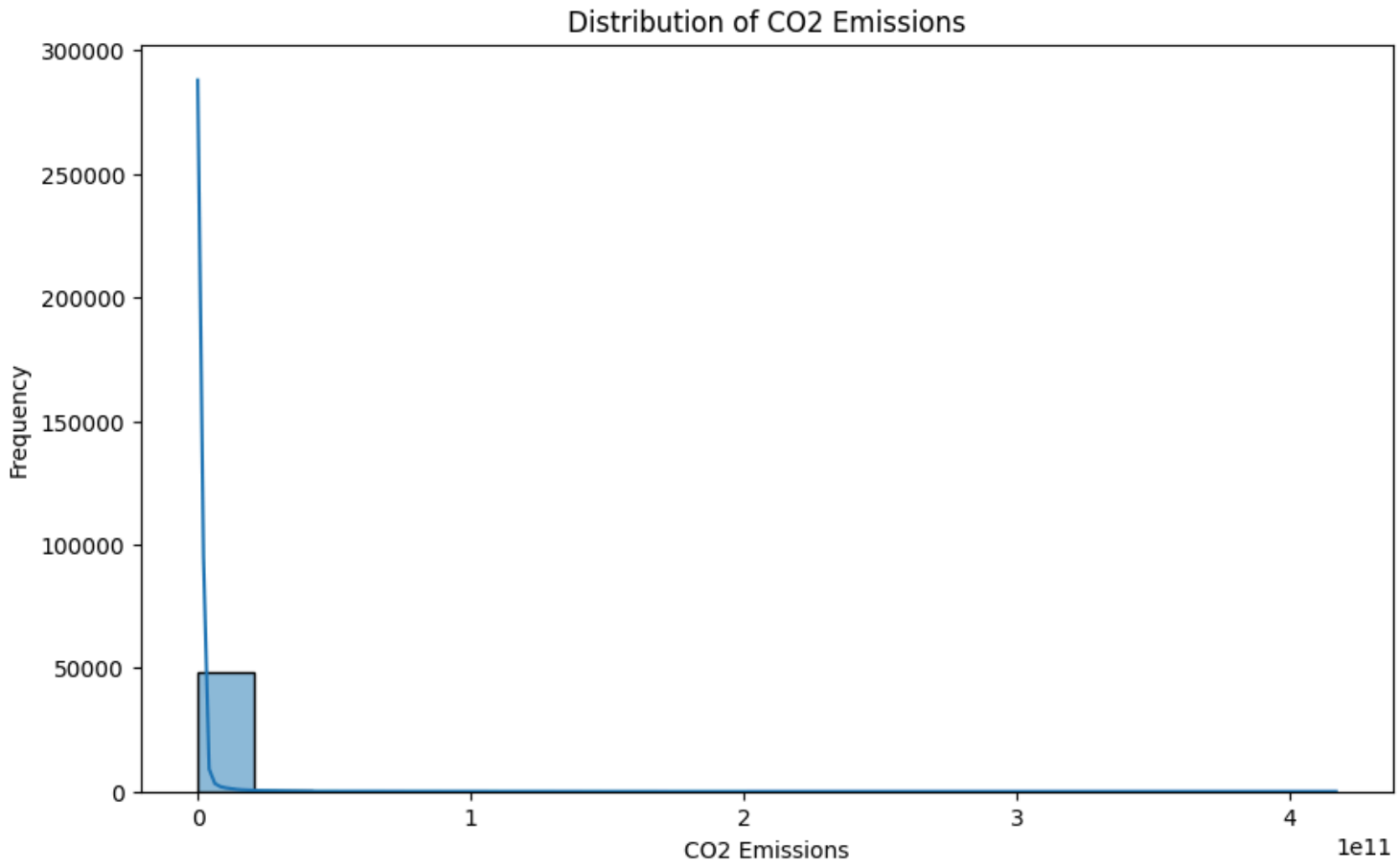
```
Country                object
Calling Code          float64
Year                    int64
CO2 emission (Tons)   float64
Population(2022)      float64
Area                  float64
% of World            float64
Density(km2)          float64
```

```
Country_Encoded          int64
dtype: object
```

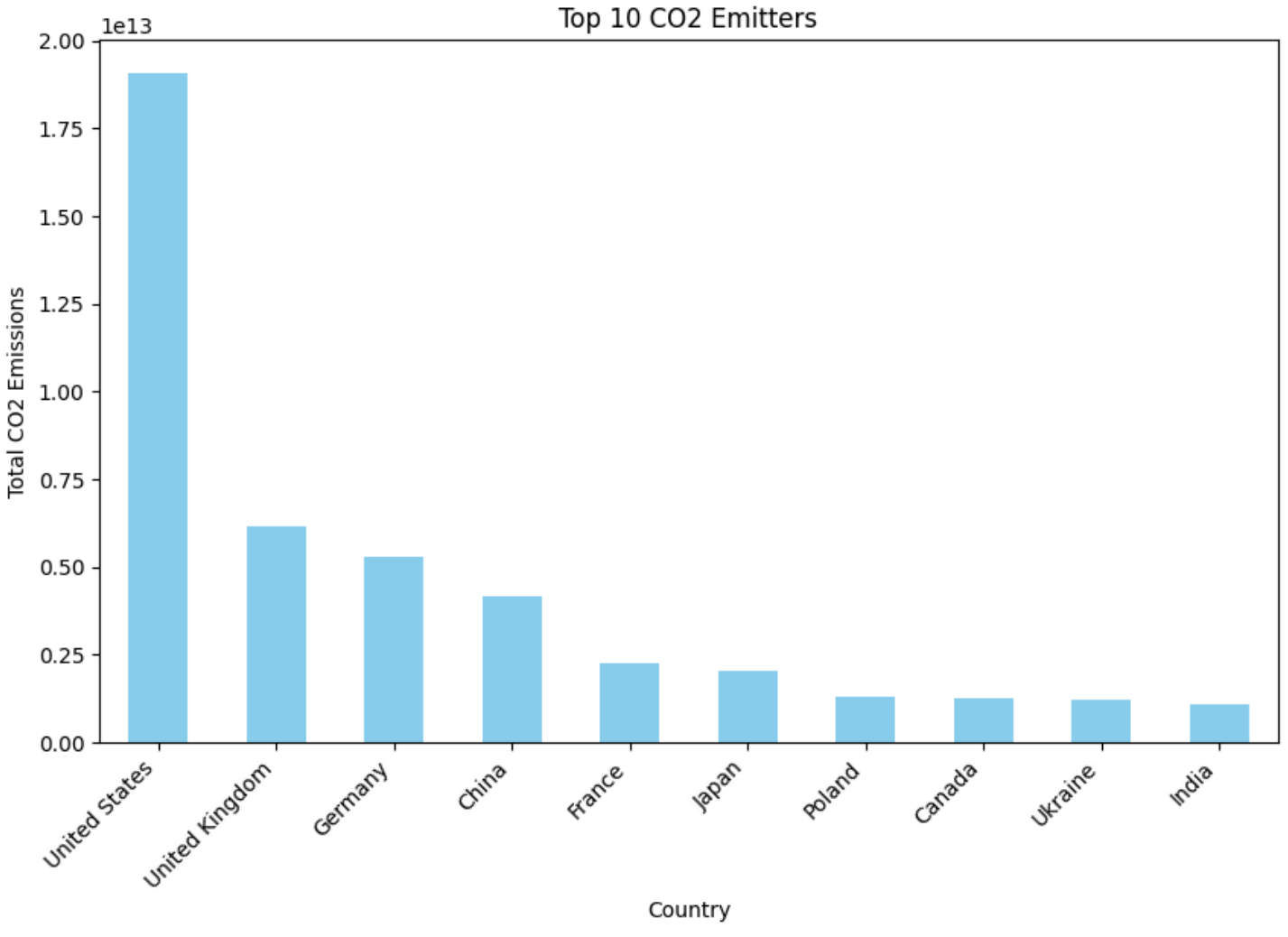
```
1
```

DATA VISUALIZATION

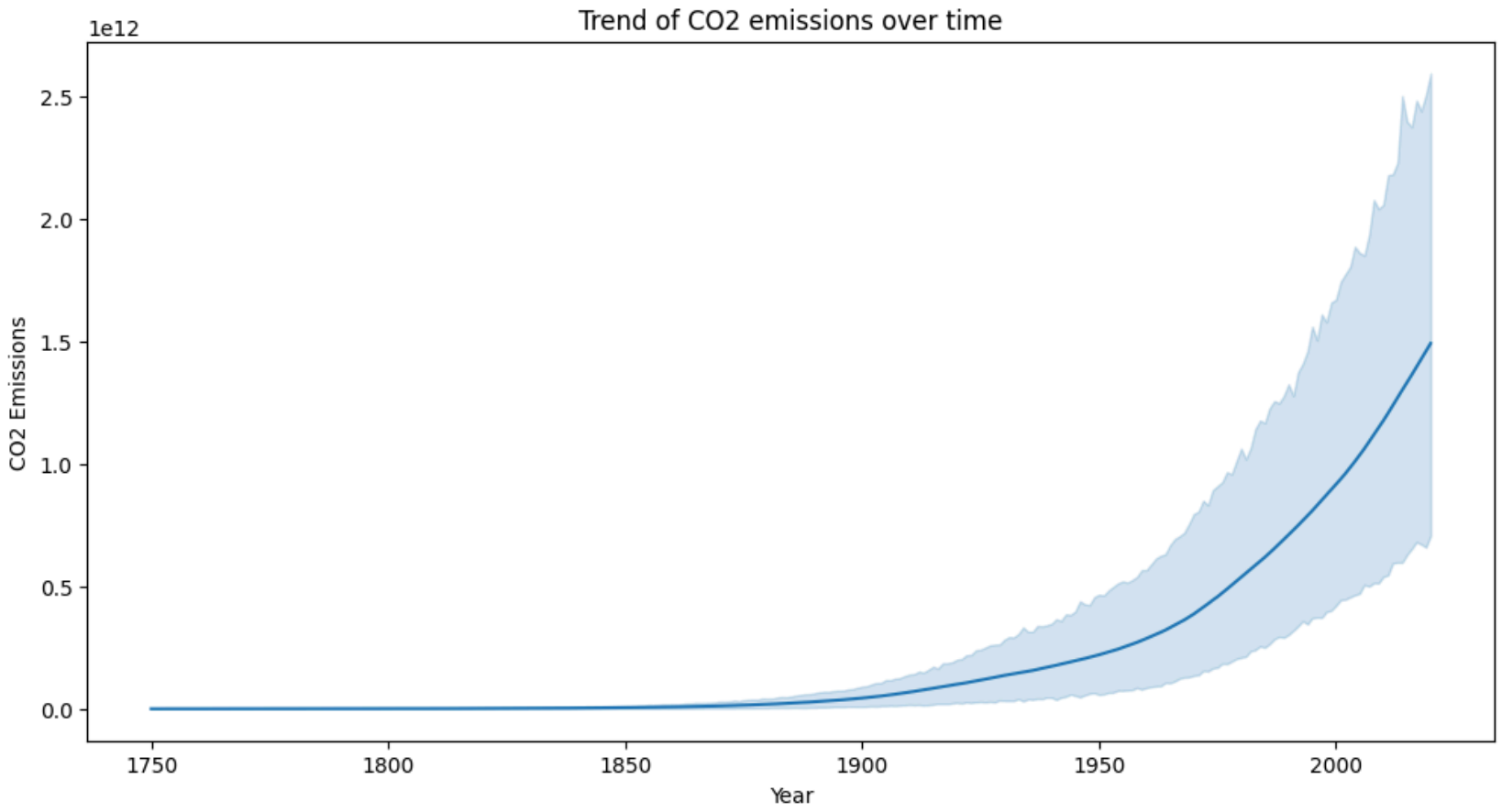
```
#Bar plot to visualize top 10 emitters:
plt.figure(figsize=(10, 6))
sns.histplot(df['CO2 emission (Tons)'], bins=20, kde=True)
plt.title('Distribution of CO2 Emissions')
plt.xlabel('CO2 Emissions')
plt.ylabel('Frequency')
plt.show()

```



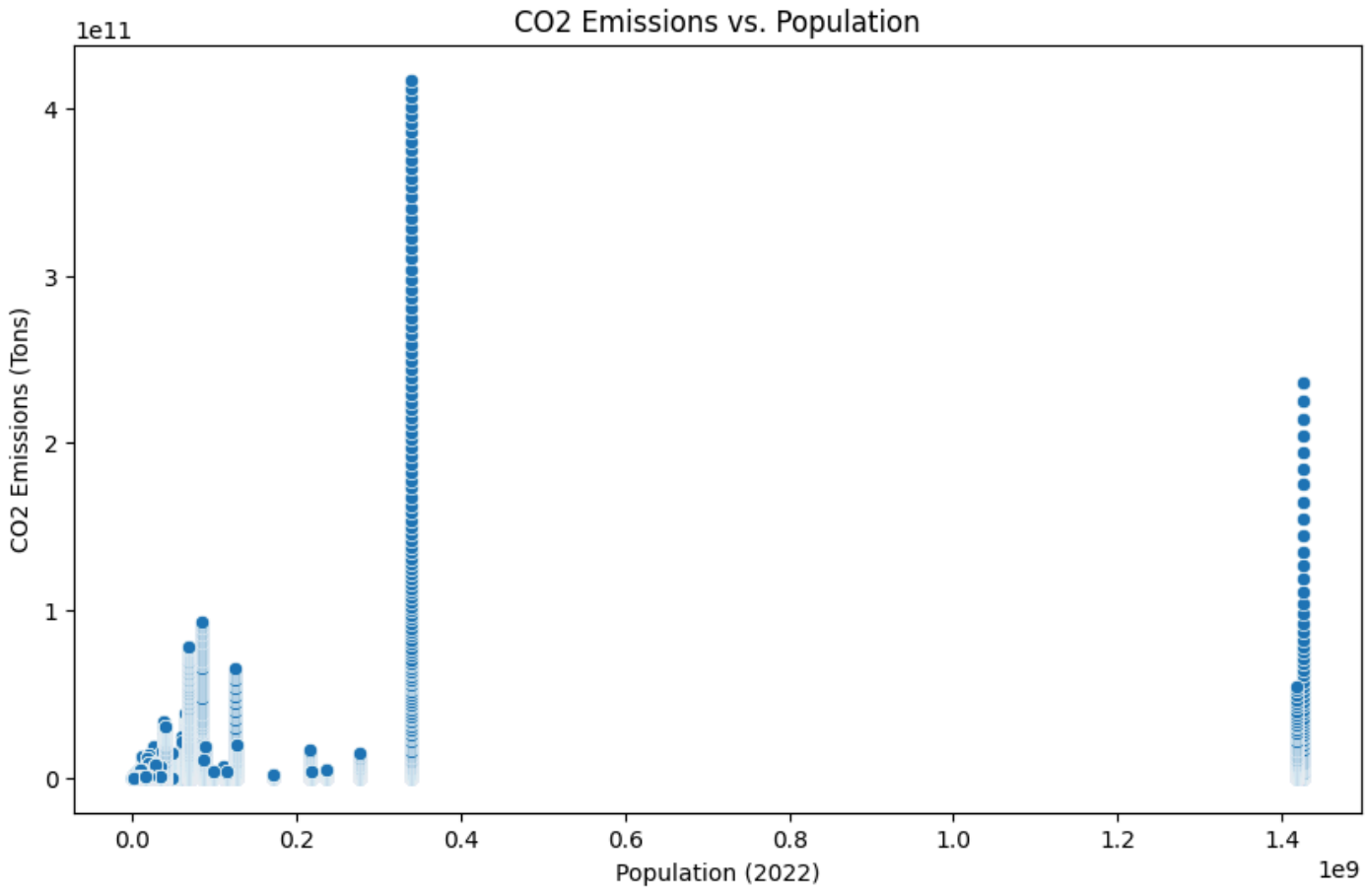

```
#Line plot to visualize trend of CO2 emissions over years:
plt.figure(figsize=(10, 6))
top_10_emitters = df.groupby('Country')['CO2 emission (Tons)'].sum().nlargest(10)
top_10_emitters.plot(kind='bar', color='skyblue')
plt.title('Top 10 CO2 Emitters')
plt.xlabel('Country')
plt.ylabel('Total CO2 Emissions')
plt.xticks(rotation=45, ha='right')
plt.show()

```



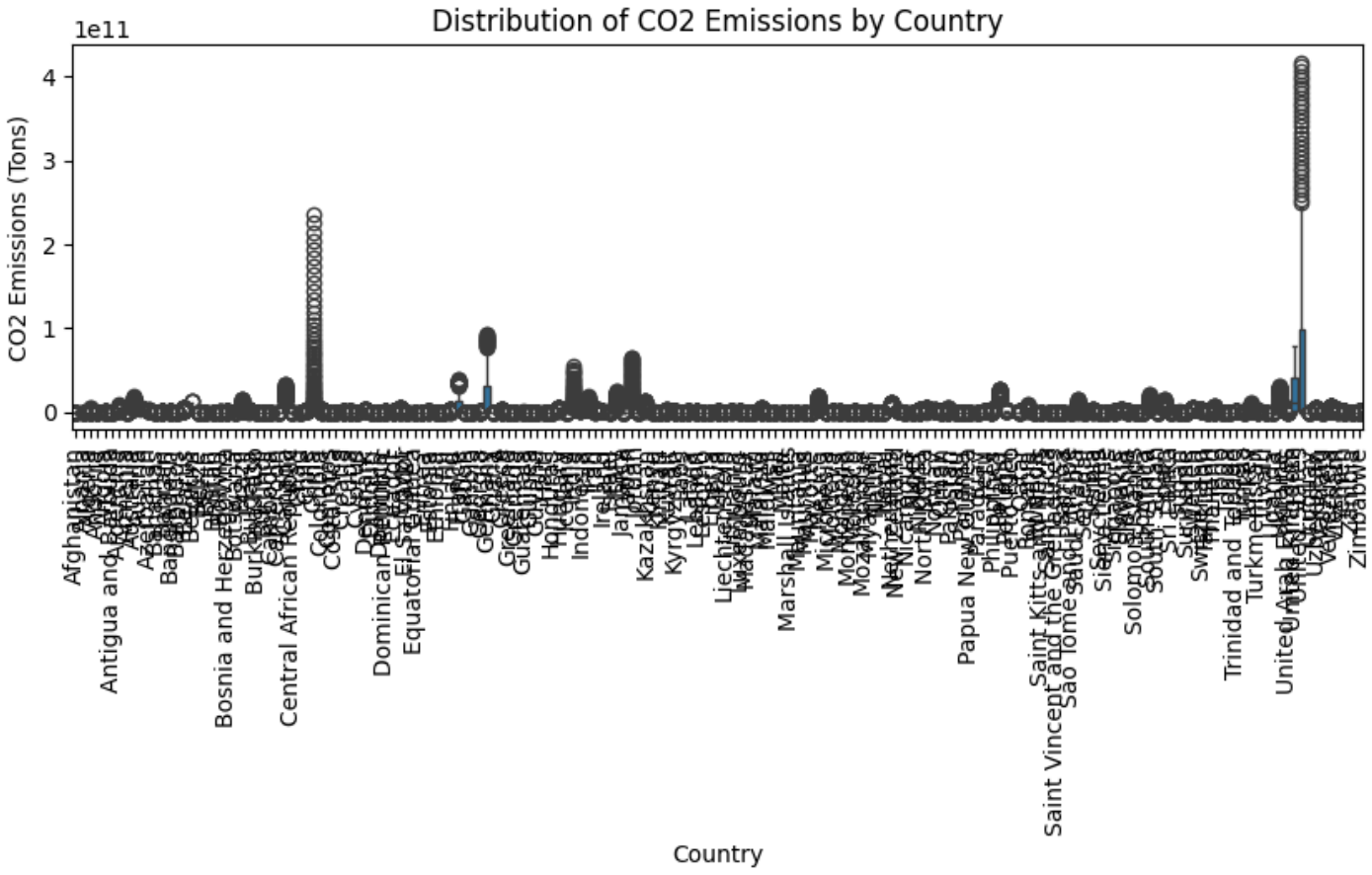
```
#Scatter plot to visualize relationship between CO2 emissions and population:
plt.figure(figsize=(12, 6))
sns.lineplot(data=df, x='Year', y='CO2 emission (Tons)', estimator='sum')
plt.title('Trend of CO2 emissions over time')
plt.xlabel('Year')
plt.ylabel('CO2 Emissions')
plt.show()

```



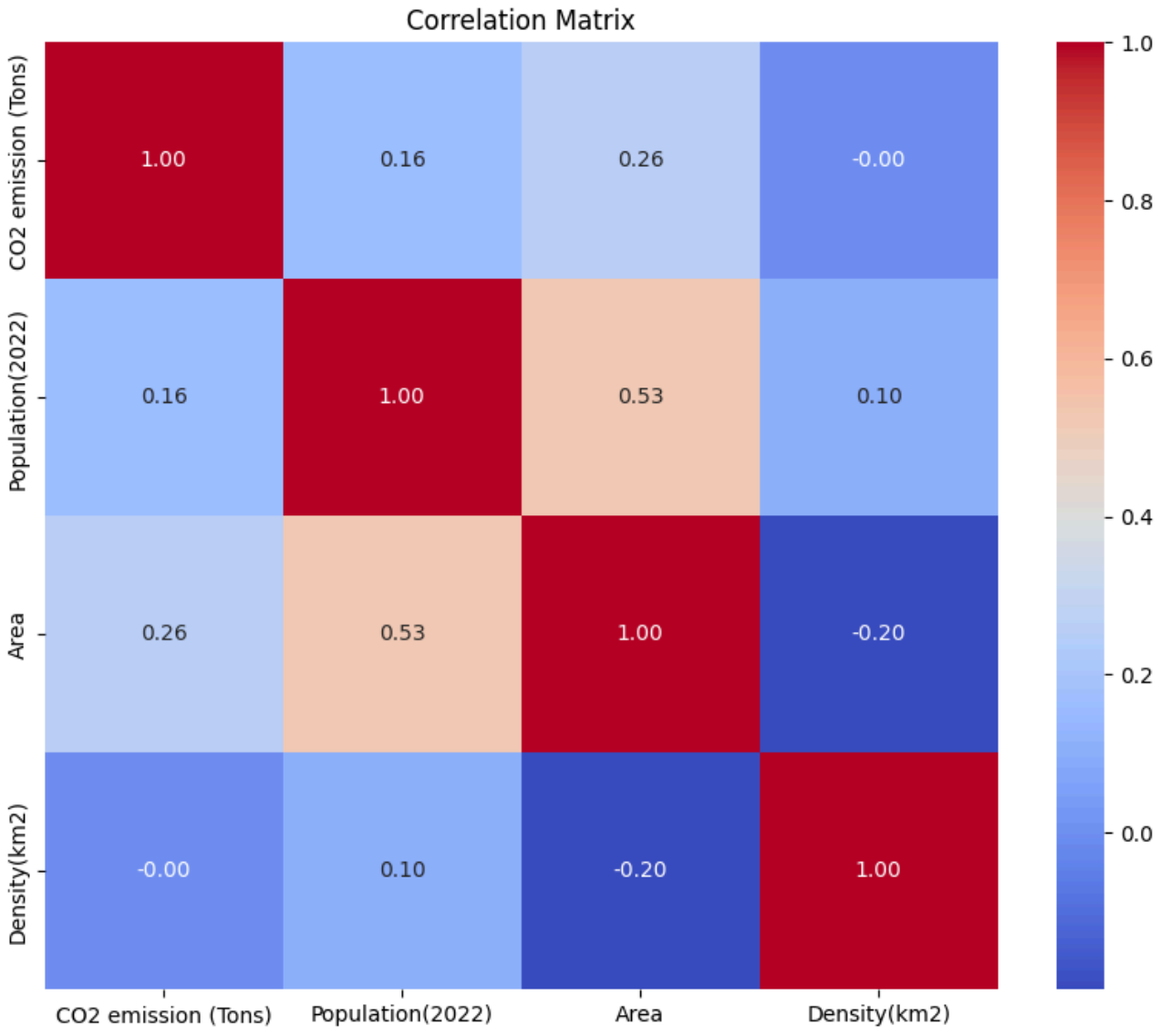

```
#Box plot to visualize distribution of CO2 emissions by country:
plt.figure(figsize=(10, 6))
sns.scatterplot(data=df, x='Population(2022)', y='CO2 emission (Tons)')
plt.title('CO2 Emissions vs. Population')
plt.xlabel('Population (2022)')
plt.ylabel('CO2 Emissions (Tons)')
plt.show()

```




```
#Box plot to visualize distribution of CO2 emissions by country:
plt.figure(figsize=(10, 3))
sns.boxplot(data=df, x='Country', y='CO2 emission (Tons)')
plt.title('Distribution of CO2 Emissions by Country')
plt.xlabel('Country')
plt.ylabel('CO2 Emissions (Tons)')
plt.xticks(rotation=90)
plt.show()

```




```
# Calculate correlation matrix
correlation_matrix = df[['CO2 emission (Tons)', 'Population(2022)', 'Area', 'Density(km2)']].corr()

# Visualize correlation matrix as a heatmap
plt.figure(figsize=(10, 8))
sns.heatmap(correlation_matrix, annot=True, cmap='coolwarm', fmt=".2f")
plt.title('Correlation Matrix')
plt.show()

```




```
# Total CO2 emissions by country(First 5)
total_emissions_by_country = df.groupby('Country')['CO2 emission (Tons)'].sum()
print(total_emissions_by_country[:5])

# Average CO2 emissions by year(First 5)
average_emissions_by_year = df.groupby('Year')['CO2 emission (Tons)'].mean()
print(average_emissions_by_year[:5])

# Total CO2 emissions by year(First 5)
total_emissions_by_year = df.groupby('Year')['CO2 emission (Tons)'].sum()
print(total_emissions_by_year[:5])

```

```
Country
Afghanistan    3.754106e+09
Albania        9.250246e+09
Algeria        9.582024e+10
Andorra        2.360722e+08
Angola         1.143158e+10
```

```
Name: CO2 emission (Tons), dtype: float64
Year
1750     52237.586592
1751    104475.173184
1752    156733.229050
1753    208991.284916
1754    261269.810056
Name: CO2 emission (Tons), dtype: float64
Year
1750     9350528.0
1751    18701056.0
1752    28055248.0
1753    37409440.0
1754    46767296.0
Name: CO2 emission (Tons), dtype: float64
```

```
# Total CO2 emissions by country
total_emissions_by_country = df.groupby("Country")["CO2 emission (Tons)"].sum().sort_values(ascending=False)

# Average CO2 emissions per capita by country
df["CO2_emission_per_capita"] = df["CO2 emission (Tons)"] / df["Population(2022)"]
average_emissions_per_capita = df.groupby("Country")["CO2_emission_per_capita"].mean().sort_values(ascending=False)
print(average_emissions_per_capita)
```

```
Country
United Kingdom    336.819255
Belgium           250.196083
Germany           234.607068
United States     208.000489
Estonia           176.211194
                     ...
Niger               0.130255
Ethiopia            0.127935
Chad                0.101320
Burundi             0.077897
Puerto Rico         0.023932
Name: CO2_emission_per_capita, Length: 179, dtype: float64
```

BUILDING PREDICTION MODEL

```
!pip install scikit-learn
```

```
Requirement already satisfied: scikit-learn in /usr/local/lib/python3.10/dist-packages (1.2.2)
Requirement already satisfied: numpy>=1.17.3 in /usr/local/lib/python3.10/dist-packages (from scikit-learn) (1.25.2)
Requirement already satisfied: scipy>=1.3.2 in /usr/local/lib/python3.10/dist-packages (from scikit-learn) (1.11.4)
Requirement already satisfied: joblib>=1.1.1 in /usr/local/lib/python3.10/dist-packages (from scikit-learn) (1.4.0)
Requirement already satisfied: threadpoolctl>=2.0.0 in /usr/local/lib/python3.10/dist-packages (from scikit-learn) (3.4.0)
```

```
from sklearn.model_selection import train_test_split
from sklearn.linear_model import LinearRegression
from sklearn.metrics import mean_squared_error
import matplotlib.pyplot as plt
```

```
print(df.head())
```

```
       Country  Calling Code  Year  CO2 emission (Tons)  Population(2022)  \
0  Afghanistan          93.0  1750                  0.0        41128771.0
1  Afghanistan          93.0  1751                  0.0        41128771.0
2  Afghanistan          93.0  1752                  0.0        41128771.0
3  Afghanistan          93.0  1753                  0.0        41128771.0
4  Afghanistan          93.0  1754                  0.0        41128771.0

       Area  % of World  Density(km2)  Country_Encoded  \
0  652230.0         0.4          63.0                0
1  652230.0         0.4          63.0                0
2  652230.0         0.4          63.0                0
3  652230.0         0.4          63.0                0
4  652230.0         0.4          63.0                0

   CO2_emission_per_capita
0                      0.0
1                      0.0
2                      0.0
3                      0.0
4                      0.0
```

```
print(df['Country_Encoded'].nunique())
```

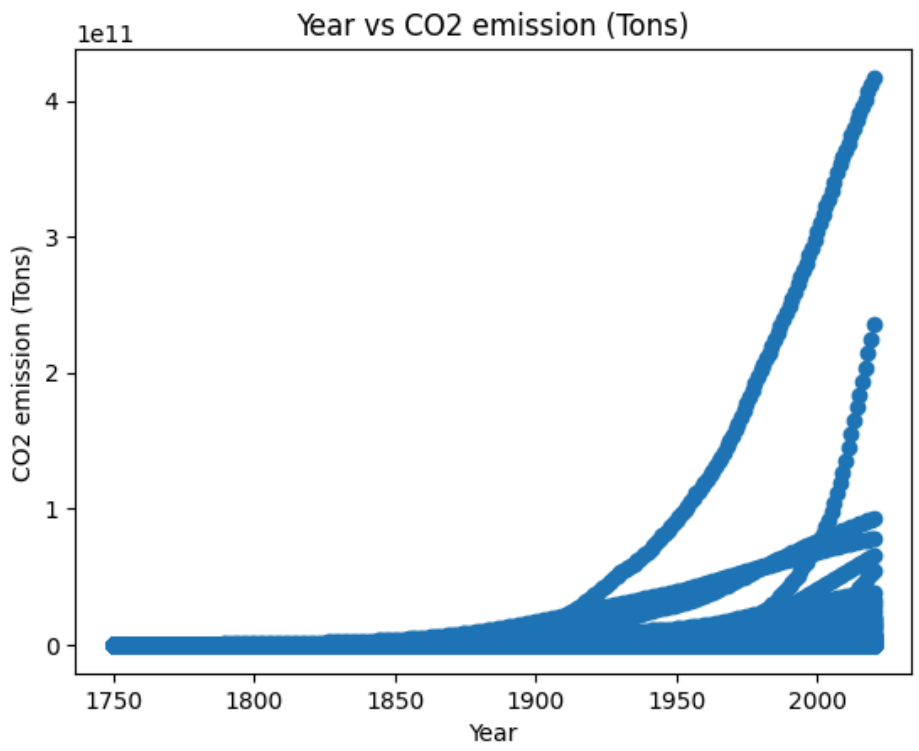
```
179
```

```
print(numeric_columns.corr())
```

```
                             Year  CO2 emission (Tons)  Population(2022)  \
Year                 1.000000e+00             0.134150     -7.233739e-15
CO2 emission (Tons)  1.341501e-01             1.000000      1.611472e-01
Population(2022)    -7.233739e-15             0.161147      1.000000e+00
Area                -1.120522e-14             0.262216      5.254822e-01

                             Area
Year                -1.120522e-14
CO2 emission (Tons)  2.622159e-01
Population(2022)     5.254822e-01
Area                 1.000000e+00
```

```
X = df[["Year", "Population(2022)"]]
y = df["CO2 emission (Tons)"]
```

```
# Plot Year against CO2 emission (Tons)
plt.scatter(X['Year'], y)
plt.xlabel('Year')
plt.ylabel('CO2 emission (Tons)')
plt.title('Year vs CO2 emission (Tons)')
plt.show()
```




```
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=42)

# Train a linear regression model
model = LinearRegression()
model.fit(X_train, y_train)
```

▾ LinearRegression
LinearRegression()

```
y_pred = model.predict(X_test)
```

```
y_pred
```

```
array([-6.18290346e+08,  7.61704583e+08,  2.57100939e+09, ...,
        3.60970282e+09,  2.77131983e+08,  6.82118759e+08])
```

```
mse = mean_squared_error(y_test, y_pred)
print("Mean Squared Error:", mse)
```

```
Mean Squared Error: 1.923505065747443e+20
```