In [138…
```python
#importing libaries
import pandas as pd
import seaborn as sns
import numpy as np
#for displaying plots
from matplotlib import pyplot as plt
%matplotlib inline

#for ignoring errors in distplot
import warnings
warnings.filterwarnings("ignore")
```

In [139…
```python
#importing data
df_consumer_price_indicator = pd.read_csv("data_prep/consumer_prices_indicators.csv")
df_crops_prod_indicator = pd.read_csv("data_prep/crops_production_indicators.csv")
df_emission = pd.read_csv("data_prep/emissions.csv")
df_exchange_rate = pd.read_csv("data_prep/exchange_rate.csv")
df_fertilizers_use = pd.read_csv("data_prep/fertilizers_use.csv")
df_food_balance_ind = pd.read_csv("data_prep/food_balances_indicators.csv")
df_food_security_indicators = pd.read_csv("data_prep/food_security_indicators.csv")
df_food_trade_indicators = pd.read_csv("data_prep/food_trade_indicators.csv")
df_foreign_invest = pd.read_csv("data_prep/foreign_direct_investment.csv")
df_land_temp = pd.read_csv("data_prep/land_temperature_change.csv")
df_land_use = pd.read_csv("data_prep/land_use.csv")
df_pest_use = pd.read_csv("data_prep/pesticides_use.csv")
```

1. Data Preprocessing

In [140…
```python
#preparing df_consumer_price_indicator data
selected_columns = ['Area Code (M49)', 'Area', 'Year','Domain', 'Item', 'Value']

# Filtering out rows where Item is 'Food price inflation'
filtered_df = df_consumer_price_indicator[selected_columns][df_consumer_price_indicator['Item'] == 'Food price ir
filtered_df.reset_index(drop=True, inplace=True)
filtered_df = filtered_df.groupby(['Area Code (M49)','Area', 'Year', 'Domain', 'Item'])['Value'].sum().reset_inde
```

In [141…
```python
filtered_consumer_price_indicator = filtered_df.copy()
```

In [142…
```python
filtered_consumer_price_indicator.rename(columns={'Value' : 'food_price_inflation'}, inplace = True)
```

In [143…
```python
filtered_consumer_price_indicator.head()
```

Out[143…

	Area Code (M49)	Area	Year	Domain	Item	food_price_inflation
0	4	Afghanistan	2001	Consumer Price Indices	Food price inflation	153.368307
1	4	Afghanistan	2002	Consumer Price Indices	Food price inflation	219.054193
2	4	Afghanistan	2003	Consumer Price Indices	Food price inflation	169.226933
3	4	Afghanistan	2004	Consumer Price Indices	Food price inflation	168.866060
4	4	Afghanistan	2005	Consumer Price Indices	Food price inflation	151.274875

In [144…
```python
columns_to_drop = ['Domain', 'Item']
filtered_consumer_price_indicator
```

Out[144…

	Area Code (M49)	Area	Year	Domain	Item	food_price_inflation
0	4	Afghanistan	2001	Consumer Price Indices	Food price inflation	153.368307
1	4	Afghanistan	2002	Consumer Price Indices	Food price inflation	219.054193
2	4	Afghanistan	2003	Consumer Price Indices	Food price inflation	169.226933
3	4	Afghanistan	2004	Consumer Price Indices	Food price inflation	168.866060
4	4	Afghanistan	2005	Consumer Price Indices	Food price inflation	151.274875
...	...	...	...	...	...	...
4648	894	Zambia	2019	Consumer Price Indices	Food price inflation	124.840069
4649	894	Zambia	2020	Consumer Price Indices	Food price inflation	194.578015
4650	894	Zambia	2021	Consumer Price Indices	Food price inflation	333.381690
4651	894	Zambia	2022	Consumer Price Indices	Food price inflation	158.242893
4652	894	Zambia	2023	Consumer Price Indices	Food price inflation	50.628100

4653 rows × 6 columns

In [145…
```
filtered_consumer_price_indicator = filtered_consumer_price_indicator[['Area','Area Code (M49)','Year','food_pric
```

In [146…
```
filtered_consumer_price_indicator.head()
```

Out[146…

	Area	Area Code (M49)	Year	food_price_inflation
0	Afghanistan	4	2001	153.368307
1	Afghanistan	4	2002	219.054193
2	Afghanistan	4	2003	169.226933
3	Afghanistan	4	2004	168.866060
4	Afghanistan	4	2005	151.274875

Crops production indicators

In [147…
```
df_crops_prod_indicator.head()
```

Out[147…

	Domain Code	Domain	Area Code (M49)	Area	Element Code	Element	Item Code (CPC)	Item	Year Code	Year	Unit	Value	Flag	Flag Description	Note
0	QCL	Crops and livestock products	4	Afghanistan	5419	Yield	F1717	Cereals, primary	2000	2000	100 g/ha	8063	A	Official figure	NaN
1	QCL	Crops and livestock products	4	Afghanistan	5419	Yield	F1717	Cereals, primary	2001	2001	100 g/ha	10067	A	Official figure	NaN
2	QCL	Crops and livestock products	4	Afghanistan	5419	Yield	F1717	Cereals, primary	2002	2002	100 g/ha	16698	A	Official figure	NaN
3	QCL	Crops and livestock products	4	Afghanistan	5419	Yield	F1717	Cereals, primary	2003	2003	100 g/ha	14580	A	Official figure	NaN
4	QCL	Crops and livestock products	4	Afghanistan	5419	Yield	F1717	Cereals, primary	2004	2004	100 g/ha	13348	A	Official figure	NaN

In [148…
```
#preparing df_crop_prod data
selected_columns = ['Area', 'Area Code (M49)', 'Year', 'Value', 'Element']

# Filtering out rows where Flag Description is 'Official figure'
filtered_df_ = df_crops_prod_indicator[selected_columns][df_crops_prod_indicator['Flag Description'] == 'Official

# Resetting index
filtered_df_.reset_index(drop=True, inplace=True)

filtered_df_ = filtered_df_.groupby(['Area','Area Code (M49)','Year','Element' ])['Value'].sum().reset_index()
```

In [149…
```
filtered_df_.head()
```

Out[149…

	Area	Area Code (M49)	Year	Element	Value
0	Afghanistan	4	2000	Yield	192298
1	Afghanistan	4	2001	Yield	194114
2	Afghanistan	4	2002	Yield	199354
3	Afghanistan	4	2003	Yield	208287
4	Afghanistan	4	2004	Yield	365228

In [150…
```
filtered_df_.drop(columns=['Element'], inplace=True)
```

In [151…
```
filtered_crops_prod_indicator = filtered_df_.copy()
```

In [152…
```
filtered_crops_prod_indicator.rename(columns={'Value' : 'yield'}, inplace = True)
```

In [153…
```
filtered_crops_prod_indicator.head()
```

Out[153…

	Area	Area Code (M49)	Year	yield
0	Afghanistan	4	2000	192298
1	Afghanistan	4	2001	194114
2	Afghanistan	4	2002	199354

3	Afghanistan	4	2003	208287
4	Afghanistan	4	2004	365228

Emission data

In [154…
```
df_emission.head()
```

Out[154…

	Domain Code	Domain	Area Code (M49)	Area	Element Code	Element	Item Code (CPC)	Item	Year Code	Year	Source Code	Source	Unit	Value	Flag	Flag Description	No
0	GCE	Emissions from Crops	4	Afghanistan	72430	Crops total (Emissions N2O)	F1712	All Crops	2000	2000	3050	FAO TIER 1	kt	0.7056	E	Estimated value	Na
1	GCE	Emissions from Crops	4	Afghanistan	72440	Crops total (Emissions CH4)	F1712	All Crops	2000	2000	3050	FAO TIER 1	kt	20.8471	E	Estimated value	Na
2	GCE	Emissions from Crops	4	Afghanistan	72430	Crops total (Emissions N2O)	F1712	All Crops	2001	2001	3050	FAO TIER 1	kt	0.7054	E	Estimated value	Na
3	GCE	Emissions from Crops	4	Afghanistan	72440	Crops total (Emissions CH4)	F1712	All Crops	2001	2001	3050	FAO TIER 1	kt	19.2605	E	Estimated value	Na
4	GCE	Emissions from Crops	4	Afghanistan	72430	Crops total (Emissions N2O)	F1712	All Crops	2002	2002	3050	FAO TIER 1	kt	1.0656	E	Estimated value	Na

In [155…
```
df_emission['Element'].unique()
```

Out[155…
```
array(['Crops total (Emissions N2O)', 'Crops total (Emissions CH4)',
       'Emissions (N2O)', 'Emissions (CO2)'], dtype=object)
```

In [156…
```
selected_columns = ['Area', 'Area Code (M49)', 'Year','Element','Value']

# Filtering out rows where Element is 'Emissions (CO2)'
filtered_df3 = df_emission[selected_columns][df_emission['Element'] == 'Emissions (CO2)']
filtered_df3.reset_index(drop=True, inplace=True)
filtered_emission = filtered_df3.groupby(['Area', 'Area Code (M49)', 'Year', 'Element'])['Value'].sum().reset_inc
```

In [157…
```
filtered_emission.rename(columns={'Value' : 'CO2'}, inplace = True)
```

In [158…
```
filtered_emission.drop(columns=['Element'], inplace=True)
```

In [159…
```
filtered_emission.head()
```

Out[159…

	Area	Area Code (M49)	Year	CO2
0	Afghanistan	4	2000	0.0
1	Afghanistan	4	2001	0.0
2	Afghanistan	4	2002	0.0
3	Afghanistan	4	2003	0.0
4	Afghanistan	4	2004	0.0

Exchange Rate

In [160…
```
selected_columns = ['Area', 'Area Code (M49)', 'Year','Value']
filtered_exchange_rate = df_exchange_rate.groupby(['Area', 'Area Code (M49)', 'Year'])['Value'].mean().reset_inde
```

In [161…
```
filtered_exchange_rate.rename(columns={'Value' : 'exchange_rate'}, inplace = True)
```

In [162…
```
filtered_exchange_rate.head()
```

Out[162…

	Area	Area Code (M49)	Year	exchange_rate
0	Afghanistan	4	1980	44.129167
1	Afghanistan	4	1981	49.479902
2	Afghanistan	4	1982	50.599608

3	Afghanistan	4	1983	50.599608
4	Afghanistan	4	1984	50.599606

Fertilizers Use

In [163…
```
df_fertilizers_use.head()
```

Out[163…

	Domain Code	Domain	Area Code (M49)	Area	Element Code	Element	Item Code	Item	Year Code	Year	Unit	Value	Flag	Flag Description
0	RFB	Fertilizers by Product	4	Afghanistan	5157	Agricultural Use	4021	NPK fertilizers	2002	2002	t	17900.0	I	Imputed value
1	RFB	Fertilizers by Product	4	Afghanistan	5157	Agricultural Use	4021	NPK fertilizers	2003	2003	t	33200.0	I	Imputed value
2	RFB	Fertilizers by Product	4	Afghanistan	5157	Agricultural Use	4021	NPK fertilizers	2004	2004	t	47700.0	I	Imputed value
3	RFB	Fertilizers by Product	4	Afghanistan	5157	Agricultural Use	4001	Urea	2004	2004	t	42300.0	I	Imputed value
4	RFB	Fertilizers by Product	4	Afghanistan	5157	Agricultural Use	4001	Urea	2005	2005	t	20577.0	I	Imputed value

In [164…
```
#preparing df_consumer_price_indicator data
selected_columns = ['Area', 'Area Code (M49)', 'Year', 'Value']

# Filtering out rows where Flag Description is Official figure
filtered_df5 = df_fertilizers_use[selected_columns][df_fertilizers_use['Flag Description'] == 'Official figure']

# Resetting index
filtered_df5.reset_index(drop=True, inplace=True)

filtered_df5 = filtered_df5.groupby(['Area', 'Area Code (M49)','Year'])['Value'].sum().reset_index()
```

In [165…
```
filtered_df5.head()
```

Out[165…

	Area	Area Code (M49)	Year	Value
0	Afghanistan	4	2018	519122.0
1	Albania	8	2002	119726.0
2	Albania	8	2003	119903.0
3	Albania	8	2004	129231.0
4	Albania	8	2005	133330.0

In [166…
```
filtered_fertilizer = filtered_df5.copy()
filtered_fertilizer.rename(columns={'Value' : 'fertilizer_used'}, inplace = True)
```

In [167…
```
filtered_fertilizer.head()
```

Out[167…

	Area	Area Code (M49)	Year	fertilizer_used
0	Afghanistan	4	2018	519122.0
1	Albania	8	2002	119726.0
2	Albania	8	2003	119903.0
3	Albania	8	2004	129231.0
4	Albania	8	2005	133330.0

Food Balance Indicator

In [168…
```
df_food_balance_ind.head()
```

Out[168…

	Domain Code	Domain	Area Code (M49)	Area	Element Code	Element	Item Code (FBS)	Item	Year Code	Year	Unit	Value	Flag	Flag Description
0	FBS	Food Balances (2010-)	4	Afghanistan	5611	Import Quantity	S2905	Cereals - Excluding Beer	2010	2010	1000 t	2000.0	E	Estimated value

1	FBS	Food Balances (2010-)	4	Afghanistan	5611	Import Quantity	S2905	Cereals - Excluding Beer	2011	2011	1000 t	2448.0	E	Estimated value
2	FBS	Food Balances (2010-)	4	Afghanistan	5611	Import Quantity	S2905	Cereals - Excluding Beer	2012	2012	1000 t	2001.0	E	Estimated value
3	FBS	Food Balances (2010-)	4	Afghanistan	5611	Import Quantity	S2905	Cereals - Excluding Beer	2013	2013	1000 t	2155.0	E	Estimated value
4	FBS	Food Balances (2010-)	4	Afghanistan	5611	Import Quantity	S2905	Cereals - Excluding Beer	2014	2014	1000 t	1840.0	E	Estimated value

In [169…

```
df_food_balance_ind['Item'].unique()
```

Out[169…

```
array(['Cereals - Excluding Beer', 'Starchy Roots', 'Sugar Crops',
       'Sugar & Sweeteners', 'Pulses', 'Treenuts', 'Oilcrops',
       'Vegetable Oils', 'Vegetables', 'Fruits - Excluding Wine',
       'Stimulants', 'Spices', 'Alcoholic Beverages', 'Meat', 'Eggs',
       'Milk - Excluding Butter', 'Fish, Seafood'], dtype=object)
```

In [170…

```
selected_columns = ['Area Code (M49)', 'Area', 'Year', 'Value','Item']

items_to_exclude = ['Meat', 'Eggs', 'Milk - Excluding Butter', 'Fish, Seafood', 'Alcoholic Beverages']


# Filtering out rows where Item is 'Food price inflation'
filtered_df7_ = df_food_balance_ind[selected_columns][(df_food_balance_ind['Element'] == 'Export Quantity') &
                                                     (~df_food_balance_ind['Item'].isin(items_to_exclude))]
# Resetting index
filtered_df7_.reset_index(drop=True, inplace=True)

filtered_df7_ = filtered_df7_.groupby(['Area Code (M49)','Area','Year'])['Value'].sum().reset_index()
```

In [171…

```
filtered_df7_.rename(columns={'Value' : 'food_balance_indicator'}, inplace = True)
```

In [172…

```
filtered_food_balance_ind = filtered_df7_.copy()
```

In [173…

```
filtered_food_balance_ind.head()
```

Out[173…

	Area Code (M49)	Area	Year	food_balance_indicator
0	4	Afghanistan	2010	360.0
1	4	Afghanistan	2011	277.0
2	4	Afghanistan	2012	198.0
3	4	Afghanistan	2013	281.0
4	4	Afghanistan	2014	412.0

Food Security Indicator

In [174…

```
df_food_security_indicators.head()
```

Out[174…

	Domain Code	Domain	Area Code (M49)	Area	Element Code	Element	Item Code	Item	Year Code	Year	Unit	Value	Flag	Flag Description	Note
0	FS	Suite of Food Security Indicators	4	Afghanistan	6121	Value	21010	Average dietary energy supply adequacy (percen...	20002002	2000-2002	%	88.0	E	Estimated value	NaN
1	FS	Suite of Food Security Indicators	4	Afghanistan	6121	Value	21010	Average dietary energy supply adequacy (percen...	20012003	2001-2003	%	89.0	E	Estimated value	NaN
2	FS	Suite of Food Security Indicators	4	Afghanistan	6121	Value	21010	Average dietary energy supply adequacy (percen...	20022004	2002-2004	%	92.0	E	Estimated value	NaN
3	FS	Suite of Food Security	4	Afghanistan	6121	Value	21010	Average dietary energy supply	20032005	2003-	%	93.0	E	Estimated	NaN

		Indicators							adequacy (percen...		2005				value	
4	FS	Suite of Food Security Indicators	4	Afghanistan	6121	Value	21010		Average dietary energy supply adequacy (percen...	20042006	2004-2006	%	94.0	E	Estimated value	NaN

In [175…

```
df_food_security_indicators['Item'].unique()
```

Out[175…

```
array(['Average dietary energy supply adequacy (percent) (3-year average)',
       'Average protein supply (g/cap/day) (3-year average)',
       'Cereal import dependency ratio (percent) (3-year average)',
       'Percent of arable land equipped for irrigation (percent) (3-year average)',
       'Value of food imports in total merchandise exports (percent) (3-year average)',
       'Political stability and absence of violence/terrorism (index)',
       'Per capita food production variability (constant 2014-2016 thousand int$ per capita)',
       'Per capita food supply variability (kcal/cap/day)',
       'Prevalence of anemia among women of reproductive age (15-49 years)',
       'Prevalence of low birthweight (percent)'], dtype=object)
```

In [176…

```
#preparing df_consumer_price_indicator data
selected_columns = ['Area','Area Code (M49)', 'Year', 'Item','Value']

# Filtering out rows where Item is in the list of items
filtered_df8 = df_food_security_indicators[selected_columns][df_food_security_indicators['Item Code'].isin(['2103

# Resetting index
filtered_df8.reset_index(drop=True, inplace=True)

filtered_df8 = filtered_df8.groupby(['Area','Area Code (M49)','Year', 'Item'])['Value'].sum().reset_index()
```

In [177…

```
filtered_df8.head()
```

Out[177…

	Area	Area Code (M49)	Year	Item	Value
0	Afghanistan	4	2000	Per capita food supply variability (kcal/cap/day)	58.0
1	Afghanistan	4	2001	Per capita food production variability (consta...	16.3
2	Afghanistan	4	2001	Per capita food supply variability (kcal/cap/day)	47.0
3	Afghanistan	4	2002	Per capita food production variability (consta...	21.0
4	Afghanistan	4	2002	Per capita food supply variability (kcal/cap/day)	71.0

In [178…

```
# Creating the pivot table
pivot_table = pd.pivot_table(filtered_df8, index=['Area','Area Code (M49)', 'Year'], columns='Item', values='Valu

# Resetting index
pivot_table.reset_index(inplace=True)

# Renaming columns
pivot_table.columns.name = None  # Remove the name of the 'Item' column
pivot_table.rename(columns={
    'Per capita food supply variability (kcal/cap/day)': 'food_supply(per capita)',
    'Per capita food production variability (constant 2014-2016 thousand int$ per capita)': 'food_production(per_
}, inplace=True)
```

In [179…

```
filtered_food_security = pivot_table.copy()
```

In [180…

```
filtered_food_security = pivot_table[['Area', 'Area Code (M49)', 'Year', 'food_production(per_capita)', 'food_sup
```

In [181…

```
filtered_food_security.head()
```

Out[181…

	Area	Area Code (M49)	Year	food_production(per_capita)	food_supply(per capita)
0	Afghanistan	4	2000	NaN	58.0
1	Afghanistan	4	2001	16.3	47.0
2	Afghanistan	4	2002	21.0	71.0
3	Afghanistan	4	2003	20.8	72.0
4	Afghanistan	4	2004	17.3	50.0

Food Trade Indicators

In [182…

```
df_food_trade_indicators.head()
```

Out[182…

	Domain Code	Domain	Area Code (M49)	Area	Element Code	Element	Item Code (CPC)	Item	Year Code	Year	Unit	Value	Flag	Flag Description	Note
0	TCL	Crops and livestock products	4	Afghanistan	5622	Import Value	F1888	Cereals and Preparations	1991	1991	1000 USD	41600.0	A	Official figure	NaN
1	TCL	Crops and livestock products	4	Afghanistan	5622	Import Value	F1888	Cereals and Preparations	1992	1992	1000 USD	25600.0	E	Estimated value	NaN
2	TCL	Crops and livestock products	4	Afghanistan	5622	Import Value	F1888	Cereals and Preparations	1993	1993	1000 USD	40000.0	E	Estimated value	NaN
3	TCL	Crops and livestock products	4	Afghanistan	5622	Import Value	F1888	Cereals and Preparations	1994	1994	1000 USD	25700.0	E	Estimated value	NaN
4	TCL	Crops and livestock products	4	Afghanistan	5622	Import Value	F1888	Cereals and Preparations	1995	1995	1000 USD	37720.0	E	Estimated value	NaN

In [183…

```
df_food_trade_indicators['Item'].unique()
```

Out[183…

```
array(['Cereals and Preparations', 'Fats and Oils (excluding Butter)',
       'Meat and Meat Preparations', 'Sugar and Honey',
       'Fruit and Vegetables', 'Dairy Products and Eggs',
       'Alcoholic Beverages', 'Non-alcoholic Beverages', 'Other food',
       'Non-food', 'Non-edible Fats and Oils', 'Tobacco'], dtype=object)
```

In [184…

```
selected_columns = ['Area', 'Area Code (M49)', 'Year', 'Value']

items_to_exclude = [ 'Dairy Products and Eggs', 'Non-food', 'Other food', 'Alcoholic Beverages', 'Meat and Meat P

# Filtering out rows where Element is 'Export Value'
filtered_df9_ = df_food_trade_indicators[selected_columns][(df_food_trade_indicators['Element'] == 'Export Value'
                                                         (~df_food_trade_indicators['Item'].isin(items_to_exclude))]
# Resetting index
filtered_df9_.reset_index(drop=True, inplace=True)

filtered_df9_ = filtered_df9_.groupby(['Area', 'Area Code (M49)', 'Year'])['Value'].sum().reset_index()
```

In [185…

```
filtered_food_trade_indicators = filtered_df9_.copy()
```

In [186…

```
filtered_food_trade_indicators.rename(columns = {'Value': 'export_value'}, inplace = True)
```

In [187…

```
filtered_food_trade_indicators.head()
```

Out[187…

	Area	Area Code (M49)	Year	export_value
0	Afghanistan	4	1991	51858.0
1	Afghanistan	4	1992	19062.0
2	Afghanistan	4	1993	21324.0
3	Afghanistan	4	1994	26907.0
4	Afghanistan	4	1995	24240.0

Foreign Invest

In [188…

```
df_foreign_invest.head()
```

Out[188…

	Domain Code	Domain	Area Code (M49)	Area	Element Code	Element	Item Code	Item	Year Code	Year	Unit	Value	Flag	Flag Description	Note
0	FDI	Foreign Direct Investment (FDI)	4	Afghanistan	6110	Value US$	23082	Total FDI inflows	2000	2000	million USD	0.17	X	Figure from international organizations	UNCTAD
1	FDI	Foreign Direct Investment (FDI)	4	Afghanistan	6110	Value US$	23082	Total FDI inflows	2001	2001	million USD	0.68	X	Figure from international organizations	UNCTAD
		Foreign Direct						Total						Figure from	

2	FDI	Investment (FDI)	4	Afghanistan	6110	Value US$	23082	FDI inflows	2002	2002	million USD	50.00	X	international organizations	UNCTAD
3	FDI	Foreign Direct Investment (FDI)	4	Afghanistan	6110	Value US$	23082	Total FDI inflows	2003	2003	million USD	57.80	X	Figure from international organizations	UNCTAD
4	FDI	Foreign Direct Investment (FDI)	4	Afghanistan	6110	Value US$	23082	Total FDI inflows	2004	2004	million USD	186.90	X	Figure from international organizations	UNCTAD

In [189…

```
df_foreign_invest['Item'].unique()
```

Out[189…

```
array(['Total FDI inflows', 'Total FDI outflows',
       'FDI inflows to Agriculture, Forestry and Fishing',
       'FDI inflows to Food, Beverages and Tobacco',
       'FDI outflows to Agriculture, Forestry and Fishing',
       'FDI outflows to Food, Beverages and Tobacco'], dtype=object)
```

In [190…

```
#preparing df_consumer_price_indicator data
selected_columns = ['Area', 'Area Code (M49)','Year', 'Item','Value']
filtered_df10_ = df_foreign_invest[selected_columns][df_foreign_invest['Item'].isin(['Total FDI inflows','Total F

# Resetting index
filtered_df10_.reset_index(drop=True, inplace=True)

filtered_df10_ = filtered_df10_.groupby(['Area','Area Code (M49)','Year', 'Item'])['Value'].sum().reset_index()
```

In [191…

```
filtered_df10_.head()
```

Out[191…

	Area	Area Code (M49)	Year	Item	Value
0	Afghanistan	4	2000	Total FDI inflows	0.17
1	Afghanistan	4	2001	Total FDI inflows	0.68
2	Afghanistan	4	2002	Total FDI inflows	50.00
3	Afghanistan	4	2003	Total FDI inflows	57.80
4	Afghanistan	4	2003	Total FDI outflows	1.00

In [192…

```
# Creating the pivot table
pivot_table = pd.pivot_table(filtered_df10_, index=['Area', 'Area Code (M49)','Year'], columns='Item', values='Va

# Resetting index
pivot_table.reset_index(inplace=True)

filtered_foreign_invest = pivot_table.copy()

# Renaming columns
pivot_table.columns.name = None
# pivot_table.rename(columns={
#     'Total FDI inflows': 'FDI_inflows_total',
#     'Total FDI outflows': 'FDI_outflows_total'
# }, inplace=True)
```

In [193…

```
filtered_foreign_invest.rename(columns={
    'Total FDI inflows': 'FDI_inflows_total',
    'Total FDI outflows': 'FDI_outflows_total'
}, inplace=True)
```

In [194…

```
filtered_foreign_invest.head()
```

Out[194…

Item	Area	Area Code (M49)	Year	FDI_inflows_total	FDI_outflows_total
0	Afghanistan	4	2000	0.17	NaN
1	Afghanistan	4	2001	0.68	NaN
2	Afghanistan	4	2002	50.00	NaN
3	Afghanistan	4	2003	57.80	1.0
4	Afghanistan	4	2004	186.90	-0.7

Land Temperature

In [195…

```
df_land_temp.head()
```

Out[195…

	Domain Code	Domain	Area Code (M49)	Area	Element Code	Element	Months Code	Months	Year Code	Year	Unit	Value	Flag	Flag Description
0	ET	Temperature change on land	4	Afghanistan	7271	Temperature change	7016	Dec–Jan–Feb	2000	2000	°c	0.618	E	Estimated value
1	ET	Temperature change on land	4	Afghanistan	7271	Temperature change	7016	Dec–Jan–Feb	2001	2001	°c	0.365	E	Estimated value
2	ET	Temperature change on land	4	Afghanistan	7271	Temperature change	7016	Dec–Jan–Feb	2002	2002	°c	1.655	E	Estimated value
3	ET	Temperature change on land	4	Afghanistan	7271	Temperature change	7016	Dec–Jan–Feb	2003	2003	°c	0.997	E	Estimated value
4	ET	Temperature change on land	4	Afghanistan	7271	Temperature change	7016	Dec–Jan–Feb	2004	2004	°c	1.883	E	Estimated value

In [196…

```
selected_columns = ['Area', 'Area Code (M49)','Year','Value']

# Filtering out rows where Element is 'Temperature change'
filtered_df11 = df_land_temp[selected_columns][df_land_temp['Element'] == 'Temperature change']
filtered_df11.reset_index(drop=True, inplace=True)
filtered_temp = filtered_df11.groupby(['Area', 'Area Code (M49)','Year'])['Value'].sum().reset_index()
```

In [197…

```
filtered_temp.rename(columns={'Value' : 'land_temp'}, inplace = True)
```

In [198…

```
filtered_temp.head()
```

Out[198…

	Area	Area Code (M49)	Year	land_temp
0	Afghanistan	4	2000	4.965
1	Afghanistan	4	2001	6.555
2	Afghanistan	4	2002	6.825
3	Afghanistan	4	2003	2.935
4	Afghanistan	4	2004	6.866

Pesticides Use

In [199…

```
df_pest_use.head()
```

Out[199…

	Domain Code	Domain	Area Code (M49)	Area	Element Code	Element	Item Code	Item	Year Code	Year	Unit	Value	Flag	Flag Description	Note
0	RP	Pesticides Use	8	Albania	5157	Agricultural Use	1357	Pesticides (total)	2000	2000	t	307.98	E	Estimated value	NaN
1	RP	Pesticides Use	8	Albania	5159	Use per area of cropland	1357	Pesticides (total)	2000	2000	kg/ha	0.44	E	Estimated value	NaN
2	RP	Pesticides Use	8	Albania	5173	Use per value of agricultural production	1357	Pesticides (total)	2000	2000	g/Int$	0.23	E	Estimated value	NaN
3	RP	Pesticides Use	8	Albania	5157	Agricultural Use	1357	Pesticides (total)	2001	2001	t	319.38	E	Estimated value	NaN
4	RP	Pesticides Use	8	Albania	5159	Use per area of cropland	1357	Pesticides (total)	2001	2001	kg/ha	0.46	E	Estimated value	NaN

In [200…

```
df_pest_use['Item'].unique()
```

Out[200…

```
array(['Pesticides (total)', 'Insecticides', 'Herbicides',
       'Fungicides and Bactericides', 'Fungicides – Seed treatments',
       'Insecticides – Seed Treatments', 'Rodenticides'], dtype=object)
```

In [201…

```
selected_columns = ['Area Code (M49)', 'Area', 'Year', 'Value']

# Filtering out rows where Item is 'Pesticides (total)' and Unit is 'kg/ha'
filtered_df12 = df_pest_use[selected_columns][(df_pest_use['Item'] == 'Pesticides (total)') &
                                               (df_pest_use['Unit'].isin(['kg/ha']))]
# Resetting index
filtered_df12.reset_index(drop=True, inplace=True)

filtered_df12 = filtered_df12.groupby(['Area Code (M49)','Area','Year'])['Value'].mean().reset_index()
```

In [202…

```
filtered_df12.head()
```

Out[202…

	Area Code (M49)	Area	Year	Value
0	8	Albania	2000	0.44
1	8	Albania	2001	0.46
2	8	Albania	2002	0.47
3	8	Albania	2003	0.49
4	8	Albania	2004	0.51

In [203…

```
filtered_pest_use = filtered_df12.copy()
filtered_pest_use.rename(columns={'Value' : 'pesticides'}, inplace = True)
```

In [204…

```
filtered_pest_use.head()
```

Out[204…

	Area Code (M49)	Area	Year	pesticides
0	8	Albania	2000	0.44
1	8	Albania	2001	0.46
2	8	Albania	2002	0.47
3	8	Albania	2003	0.49
4	8	Albania	2004	0.51

land_use

In [205…

```
df_land_use.head()
```

Out[205…

	Domain Code	Domain	Area Code (M49)	Area	Element Code	Element	Item Code	Item	Year Code	Year	Unit	Value	Flag	Flag Description	Note
0	RL	Land Use	4	Afghanistan	5110	Area	6600	Country area	1980	1980	1000 ha	65286.0	A	Official figure	NaN
1	RL	Land Use	4	Afghanistan	5110	Area	6600	Country area	1981	1981	1000 ha	65286.0	A	Official figure	NaN
2	RL	Land Use	4	Afghanistan	5110	Area	6600	Country area	1982	1982	1000 ha	65286.0	A	Official figure	NaN
3	RL	Land Use	4	Afghanistan	5110	Area	6600	Country area	1983	1983	1000 ha	65286.0	A	Official figure	NaN
4	RL	Land Use	4	Afghanistan	5110	Area	6600	Country area	1984	1984	1000 ha	65286.0	A	Official figure	NaN

In [206…

```
selected_columns = ['Area', 'Area Code (M49)','Year', 'Value']

# Filtering out rows where Item is 'Cropland' and Flag Description is 'Official figure'
filtered_df13 = df_land_use[selected_columns][(df_land_use['Item'] == 'Cropland') &
                                              (df_land_use['Flag Description'].isin(['Official figure']))
# Resetting index
filtered_df13.reset_index(drop=True, inplace=True)

filtered_df13 = filtered_df13.groupby(['Area', 'Area Code (M49)','Year'])['Value'].sum().reset_index()
```

In [207…

```
filtered_land_use = filtered_df13.copy()
filtered_land_use.rename(columns={'Value' : 'land_used'}, inplace = True)
```

In [208…

```
filtered_land_use.head()
```

Out[208…

	Area	Area Code (M49)	Year	land_used
0	Afghanistan	4	1980	8049.0
1	Afghanistan	4	1981	8053.0
2	Afghanistan	4	1982	8054.0
3	Afghanistan	4	1983	8054.0
4	Afghanistan	4	1984	8054.0

In [209…

```
## Merging Data
```

```
merged_table_test = pd.merge(filtered_crops_prod_indicator, filtered_consumer_price_indicator, on=['Area Code (M4
merged_table_test = pd.merge(merged_table_test, filtered_emission, on=['Area Code (M49)','Area','Year'], how='out
merged_table_test = pd.merge(merged_table_test, filtered_exchange_rate, on=['Area Code (M49)','Area','Year'], how
merged_table_test = pd.merge(merged_table_test, filtered_fertilizer, on=['Area Code (M49)','Area','Year'], how='o
merged_table_test = pd.merge(merged_table_test, filtered_food_balance_ind, on=['Area Code (M49)','Area','Year'],
merged_table_test=pd.merge(merged_table_test, filtered_food_trade_indicators, on=['Area Code (M49)','Area','Year'
merged_table_test = pd.merge(merged_table_test, filtered_foreign_invest, on=['Area Code (M49)','Area','Year'], ho
merged_table_test = pd.merge(merged_table_test, filtered_temp, on=['Area Code (M49)','Area','Year'], how='outer')
merged_table_test = pd.merge(merged_table_test, filtered_pest_use, on=['Area Code (M49)','Area','Year'], how='out
merged_table_test = pd.merge(merged_table_test, filtered_land_use, on=['Area Code (M49)','Area','Year'], how='out
```

In [210…

```
filtered_food_security.head()
```

Out[210…

	Area	Area Code (M49)	Year	food_production(per_capita)	food_supply(per capita)
0	Afghanistan	4	2000	NaN	58.0
1	Afghanistan	4	2001	16.3	47.0
2	Afghanistan	4	2002	21.0	71.0
3	Afghanistan	4	2003	20.8	72.0
4	Afghanistan	4	2004	17.3	50.0

In [211…

```
merged_table_test.dtypes
```

Out[211…

```
Area                           object
Area Code (M49)                 int64
Year                            int64
yield                         float64
food_price_inflation          float64
CO2                           float64
exchange_rate                 float64
fertilizer_used               float64
food_balance_indicator        float64
export_value                  float64
FDI_inflows_total             float64
FDI_outflows_total            float64
land_temp                     float64
pesticides                    float64
land_used                     float64
dtype: object
```

In [212…

```
filtered_food_security['Area'] = filtered_food_security['Area'].astype('object')
filtered_food_security['Year'] = filtered_food_security['Year'].astype('int')
```

In [213…

```
filtered_food_security.head()
```

Out[213…

	Area	Area Code (M49)	Year	food_production(per_capita)	food_supply(per capita)
0	Afghanistan	4	2000	NaN	58.0
1	Afghanistan	4	2001	16.3	47.0
2	Afghanistan	4	2002	21.0	71.0
3	Afghanistan	4	2003	20.8	72.0
4	Afghanistan	4	2004	17.3	50.0

In [ ]:

In [214…

```
filtered_food_security.dtypes
```

Out[214…

```
Area                                object
Area Code (M49)                      int64
Year                                 int64
food_production(per_capita)        float64
food_supply(per capita)            float64
dtype: object
```

In [215…

```
merged_table_test = pd.merge(merged_table_test, filtered_food_security, on=['Area Code (M49)','Area','Year'], how
```

In [216…

```
merged_table_test.head()
```

Out[216…

	Area	Area Code	Year	yield	food_price_inflation	CO2	exchange_rate	fertilizer_used	food_balance_indicator	export_value	FDI_inflow

	Area	Area Code (M49)	Year	yield	food_price_inflation	CO2	exchange_rate	fertilizer_used	food_balance_indicator	export_value
0	Afghanistan	4	2000	192298.0	NaN	0.0	47357.574730	NaN	NaN	31080.0
1	Afghanistan	4	2001	194114.0	153.368307	0.0	47500.014520	NaN	NaN	27110.0
2	Afghanistan	4	2002	199354.0	219.054193	0.0	3981.907750	NaN	NaN	31153.0
3	Afghanistan	4	2003	208287.0	169.226933	0.0	48.762754	NaN	NaN	47612.0
4	Afghanistan	4	2004	365228.0	168.866060	0.0	47.845313	NaN	NaN	48633.0

In [217…
```
merged_table_test.shape
```
Out[217…
```
(9761, 17)
```

In [218…
```
#drop Duplicates
merged_table_test = merged_table_test.drop_duplicates()
```

In [219…
```
merged_table_test.shape
```
Out[219…
```
(9761, 17)
```

In [220…
```
merged_table_test.columns
```
Out[220…
```
Index(['Area', 'Area Code (M49)', 'Year', 'yield', 'food_price_inflation',
       'CO2', 'exchange_rate', 'fertilizer_used', 'food_balance_indicator',
       'export_value', 'FDI_inflows_total', 'FDI_outflows_total', 'land_temp',
       'pesticides', 'land_used', 'food_production(per_capita)',
       'food_supply(per capita)'],
      dtype='object')
```

Data Wrangling

In [221…
```
merged_table_test.head()
```
Out[221…

	Area	Area Code (M49)	Year	yield	food_price_inflation	CO2	exchange_rate	fertilizer_used	food_balance_indicator	export_value	FDI_inflow
0	Afghanistan	4	2000	192298.0	NaN	0.0	47357.574730	NaN	NaN	31080.0	
1	Afghanistan	4	2001	194114.0	153.368307	0.0	47500.014520	NaN	NaN	27110.0	
2	Afghanistan	4	2002	199354.0	219.054193	0.0	3981.907750	NaN	NaN	31153.0	
3	Afghanistan	4	2003	208287.0	169.226933	0.0	48.762754	NaN	NaN	47612.0	
4	Afghanistan	4	2004	365228.0	168.866060	0.0	47.845313	NaN	NaN	48633.0	

In [222…
```
merged_table_test.shape
```
Out[222…
```
(9761, 17)
```

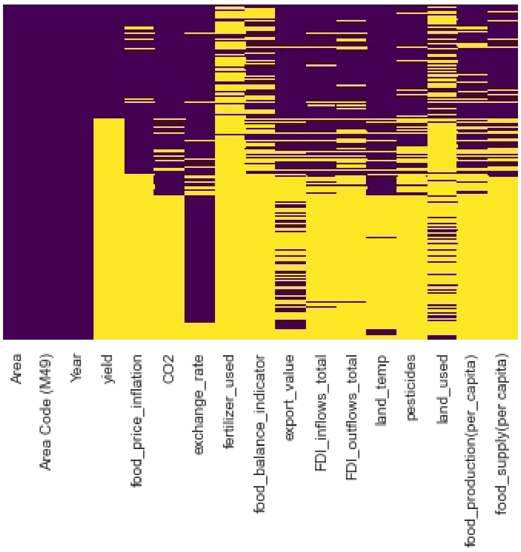
Checking Null Values

In [223…
```
# Checking Null Values
merged_table_test.isnull().sum()
```
Out[223…
```
Area                          0
Area Code (M49)               0
Year                          0
yield                      6406
food_price_inflation       5108
CO2                        4631
exchange_rate              1122
fertilizer_used            8853
food_balance_indicator     7585
export_value               3636
FDI_inflows_total          5195
```

```
FDI_outflows_total            6182
land_temp                     4280
pesticides                    5686
land_used                     6750
food_production(per_capita)   5841
food_supply(per capita)       5985
dtype: int64
```

In [224…
```python
sns.heatmap(merged_table_test.isnull(),yticklabels=False,cbar=False,cmap='viridis')
```

Out[224…
```
<AxesSubplot:>
```



In [225…
```python
merged_table_test.fillna(0, inplace = True)
```

In [226…
```python
merged_table_test.isnull().sum()
```

Out[226…
```
Area                          0
Area Code (M49)               0
Year                          0
yield                         0
food_price_inflation          0
CO2                           0
exchange_rate                 0
fertilizer_used               0
food_balance_indicator        0
export_value                  0
FDI_inflows_total             0
FDI_outflows_total            0
land_temp                     0
pesticides                    0
land_used                     0
food_production(per_capita)   0
food_supply(per capita)       0
dtype: int64
```

In [227…
```python
df_filtered2 = merged_table_test.copy()
```

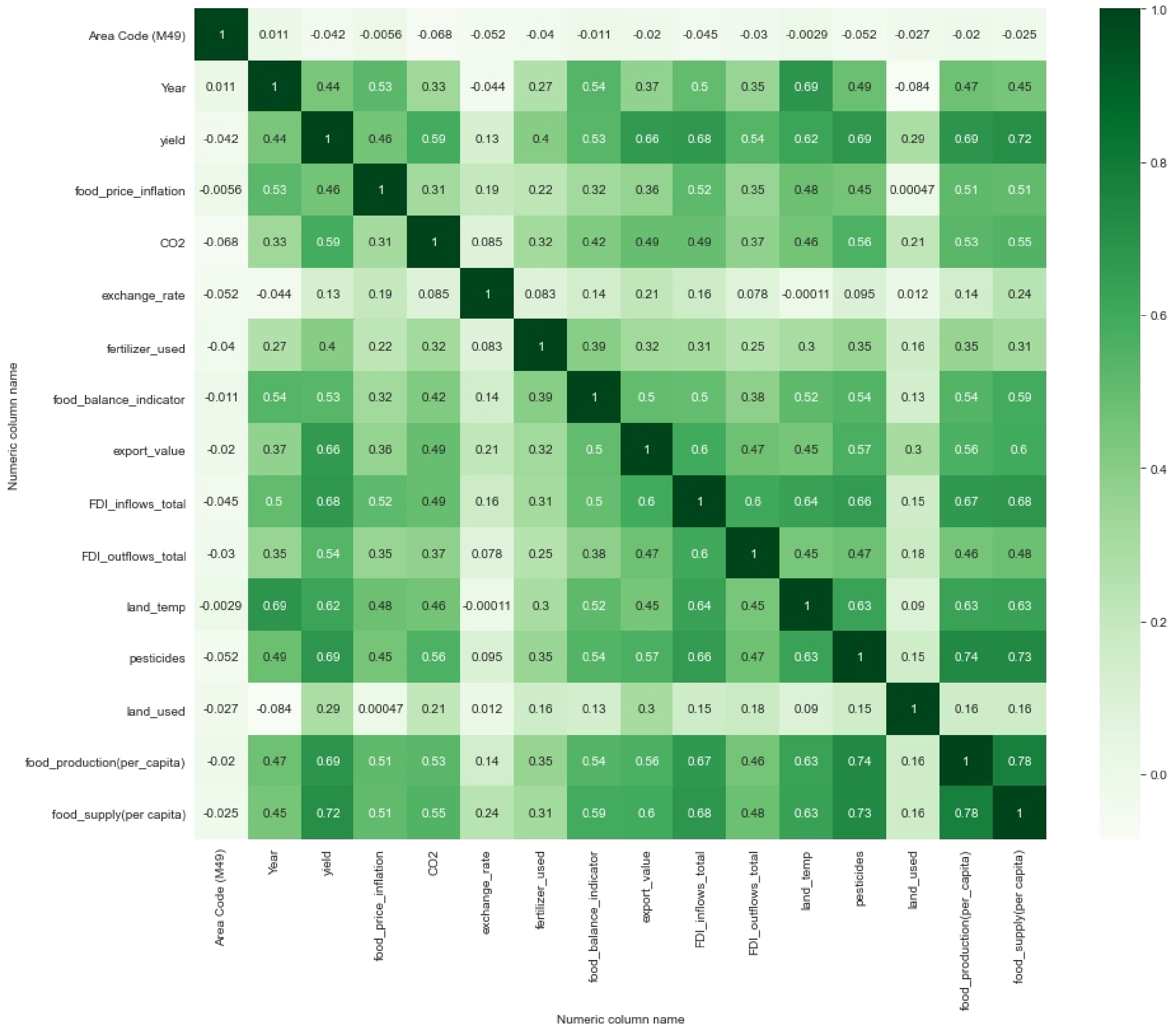
In [228…
```python
df_filtered2.drop(columns='Area', inplace = True) # Droping Area column
```

In [229…
```python
df_filtered_outlier = df_filtered2.copy()
```

In [230…
```python
# creating correlationMatrix graph
correlationMatrix = df_filtered_outlier.corr(method='spearman')
plt.figure(figsize=(15,12))
plt.title('Correlation Matrix of all numeric variables')
sns.heatmap(correlationMatrix, cmap="Greens",annot=True)
plt.xlabel('Numeric column name')
plt.ylabel('Numeric column name')
plt.plot()
```

Out[230…
```
[]
```

Correlation Matrix of all numeric variables



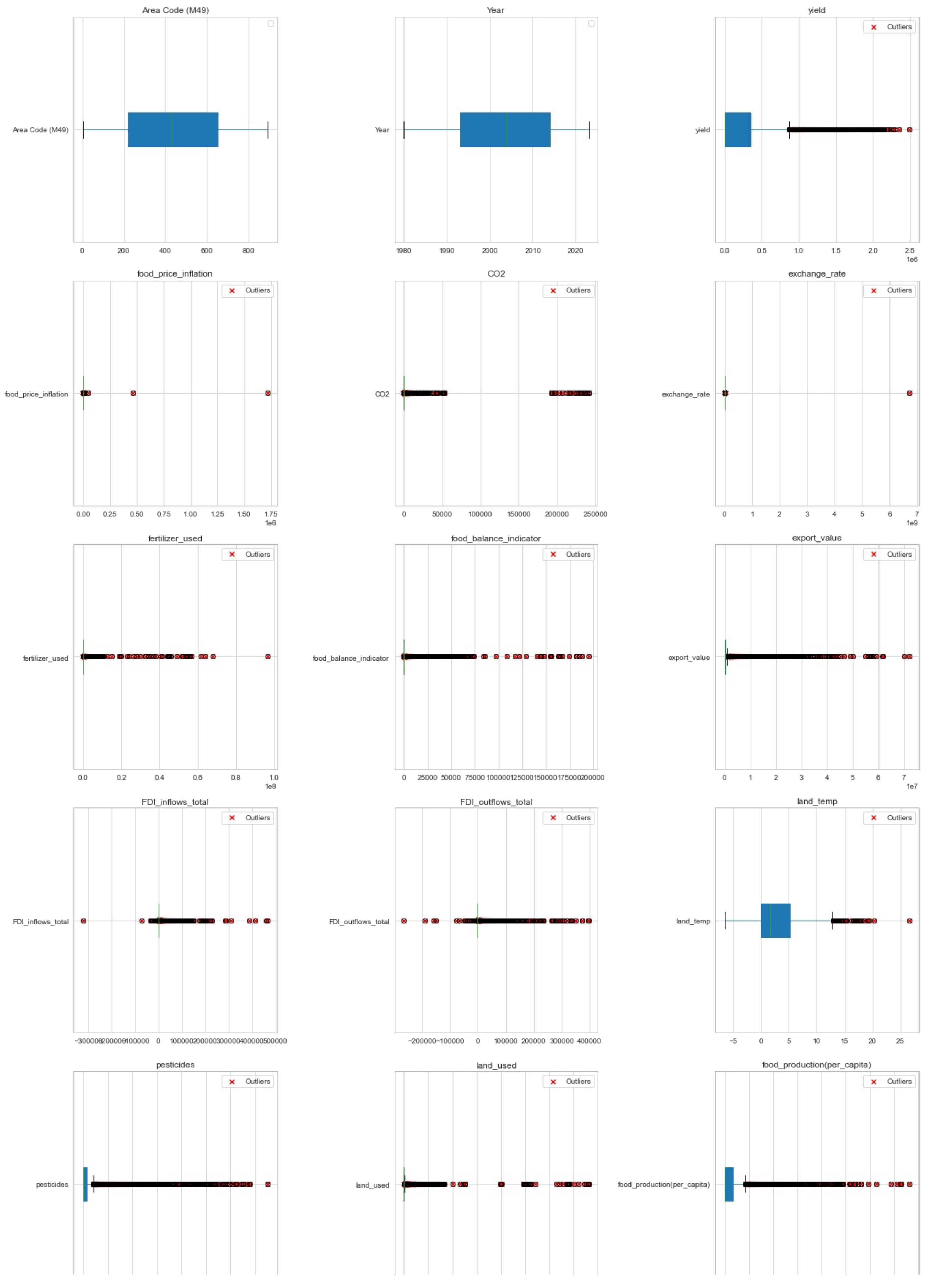
Removing Outlier

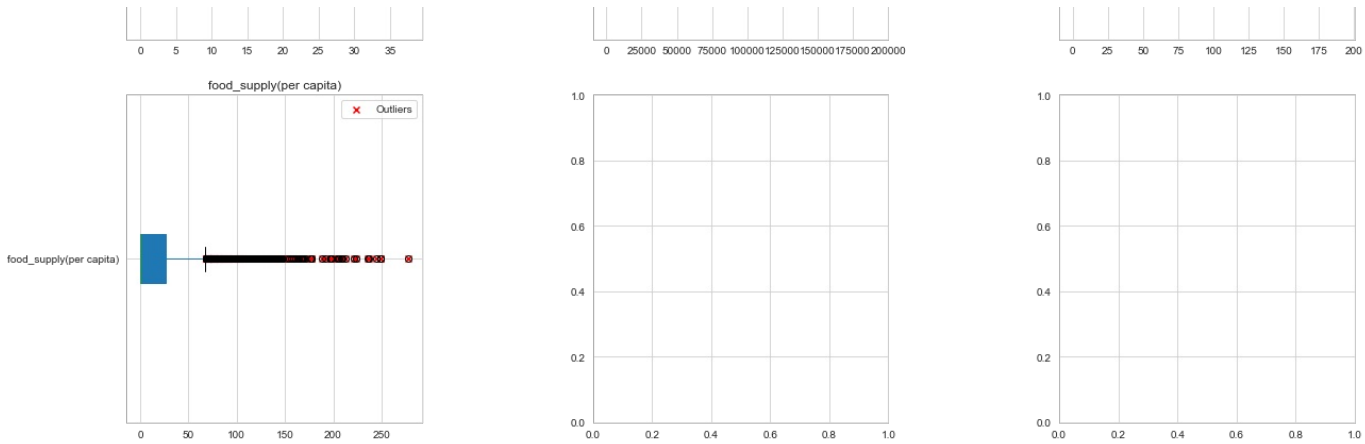
In [231…

```
def plot_outliers(df):
    # Convert columns to numeric if possible
    df = df.apply(pd.to_numeric, errors='ignore')

    num_cols = 3
    num_rows = (len(df.columns) + num_cols - 1) // num_cols

    # Define figure and axes for plotting
    fig, axes = plt.subplots(nrows=num_rows, ncols=num_cols, figsize=(18, 5*num_rows))
    axes = axes.flatten()

    # Iterate over each column in the DataFrame
    for i, col in enumerate(df.columns):
        # Convert the column to numeric
        df[col] = pd.to_numeric(df[col], errors='coerce')

        # Create a box plot for the column
        df.boxplot(column=col, ax=axes[i], vert=False, patch_artist=True)

        # Calculating the IQR (Interquartile Range) for the column
        Q1 = df[col].quantile(0.25)
        Q3 = df[col].quantile(0.75)
        IQR = Q3 - Q1

        # Define the lower and upper bounds for outlier detection
        lower_bound = Q1 - 1.5 * IQR
        upper_bound = Q3 + 1.5 * IQR

        outliers = df[(df[col] < lower_bound) | (df[col] > upper_bound)]

        # Plot outliers
        if not outliers.empty:
            axes[i].scatter(outliers[col], [1] * len(outliers), color='red', label='Outliers', marker='x')
```

```
        axes[i].set_title(col)
        axes[i].legend()

    plt.tight_layout()
    plt.show()

# Plot outliers using box plots in the merged table
plot_outliers(df_filtered_outlier)
```

```
No handles with labels found to put in legend.
No handles with labels found to put in legend.
```





In [232…

```
columns = df_filtered_outlier.columns
print(columns)
```

```
Index(['Area Code (M49)', 'Year', 'yield', 'food_price_inflation', 'CO2',
       'exchange_rate', 'fertilizer_used', 'food_balance_indicator',
       'export_value', 'FDI_inflows_total', 'FDI_outflows_total', 'land_temp',
       'pesticides', 'land_used', 'food_production(per_capita)',
       'food_supply(per capita)'],
      dtype='object')
```

In [233…

```
merged_table_test.drop(columns = ['Area'], inplace = True)
```

In [234…

```
merged_table_test.shape
```

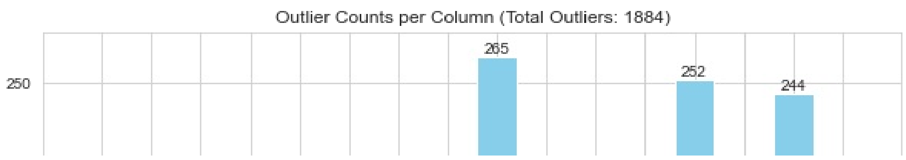
Out[234… (9761, 16)

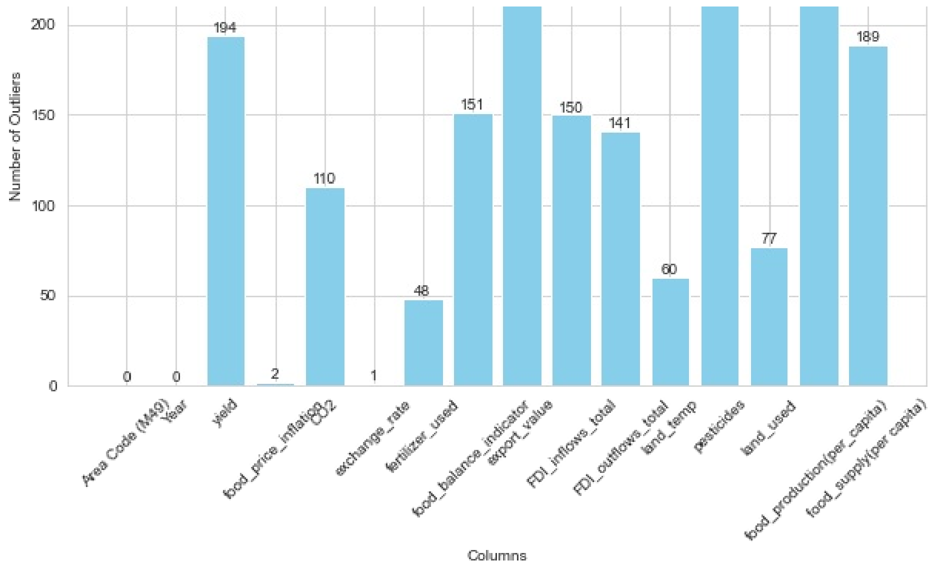
In [235…

```
import numpy as np

def out_zscore(data):
    outliers = []
    zscore = []
    threshold = 3
    mean = np.mean(data)
    std = np.std(data)
    for i in data:
        z_score = (i - mean) / std
        zscore.append(z_score)
        if np.abs(z_score) > threshold:
            outliers.append(i)
#     print("Total number of outliers are", len(outliers))
    return outliers
```

In [236…

```
columns = merged_table_test.columns
outliers_dict = {}  # Dictionary to store outlier counts per column
total_outliers = 0  # Total number of outliers

for col in columns:
    outliers = out_zscore(df_filtered_outlier[col])
    outliers_dict[col] = len(outliers)  # Store the count of outliers for each column
    total_outliers += len(outliers)  # Update the total number of outliers

# Visualize outlier counts
plt.figure(figsize=(10, 6))
bars = plt.bar(outliers_dict.keys(), outliers_dict.values(), color='skyblue')
plt.xlabel('Columns')
plt.ylabel('Number of Outliers')
plt.title('Outlier Counts per Column (Total Outliers: {})'.format(total_outliers))
plt.xticks(rotation=45)  # Rotate x-axis labels for better visibility

# Add text annotations on top of each bar
for bar in bars:
    yval = bar.get_height()
    plt.text(bar.get_x() + bar.get_width()/2, yval, int(yval), ha='center', va='bottom')

plt.show()
```





In [237…

```python
columns = merged_table_test.columns
filtered_df = merged_table_test.copy()  # Make a copy to preserve the original DataFrame

for col in columns:
    outliers = out_zscore(df_filtered_outlier[col])
    filtered_df = filtered_df[~filtered_df[col].isin(outliers)] # new dataframe after outlier

print("Shape of DataFrame after removing outliers:", filtered_df.shape)
```

```
Shape of DataFrame after removing outliers: (8506, 16)
```

In [238…

```python
filtered_df.head()
```

Out[238…

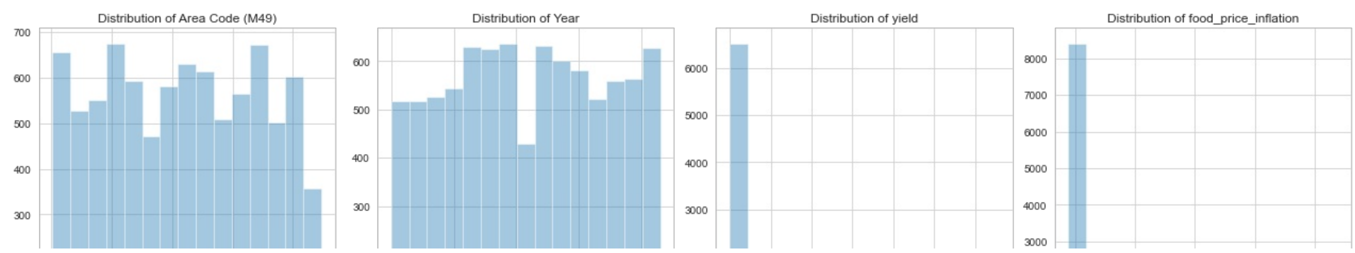
	Area Code (M49)	Year	yield	food_price_inflation	CO2	exchange_rate	fertilizer_used	food_balance_indicator	export_value	FDI_inflows_total	FDI_
0	4	2000	192298.0	0.000000	0.0	47357.574730	0.0	0.0	31080.0	0.17	
1	4	2001	194114.0	153.368307	0.0	47500.014520	0.0	0.0	27110.0	0.68	
2	4	2002	199354.0	219.054193	0.0	3981.907750	0.0	0.0	31153.0	50.00	
3	4	2003	208287.0	169.226933	0.0	48.762754	0.0	0.0	47612.0	57.80	
4	4	2004	365228.0	168.866060	0.0	47.845313	0.0	0.0	48633.0	186.90	

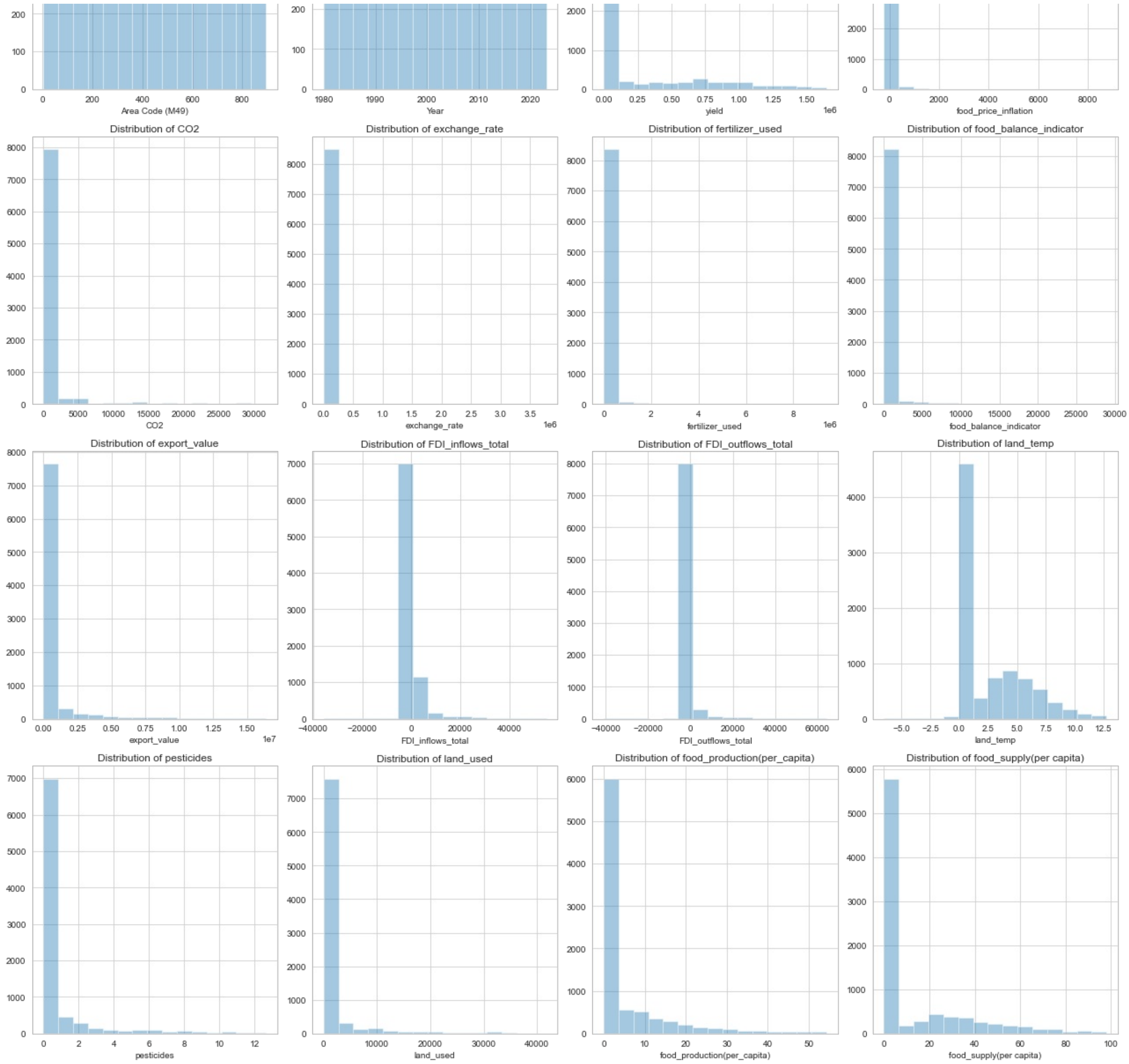
In [ ]:

Data Distribution

In [239…

```python
def distplot_df(df, columns):
    num_cols = 4
    num_rows = (len(columns) + num_cols - 1) // num_cols

    fig, axes = plt.subplots(nrows=num_rows, ncols=num_cols, figsize=(18, 5*num_rows))
    axes = axes.flatten()

    for i, col in enumerate(columns):
        sns.distplot(df[col], bins=15, kde=False, ax=axes[i])
        axes[i].set_title(f'Distribution of {col}')

    plt.tight_layout()
    plt.show()

columns = filtered_df.columns
distplot_df(filtered_df, columns)
```

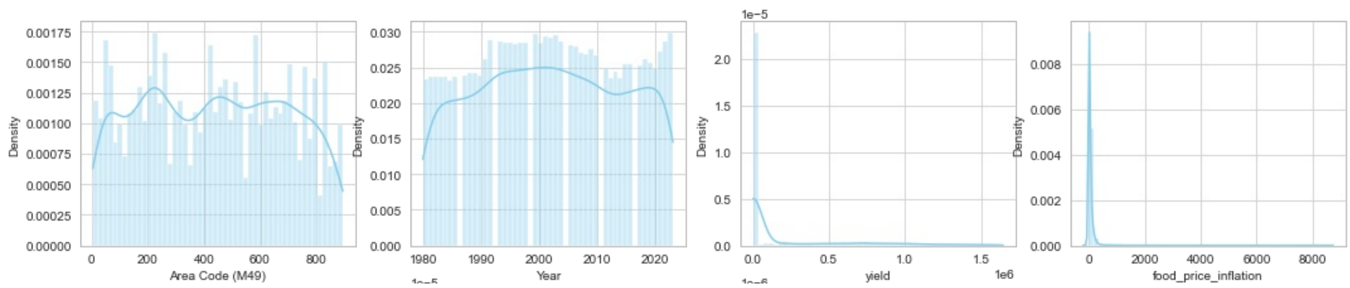


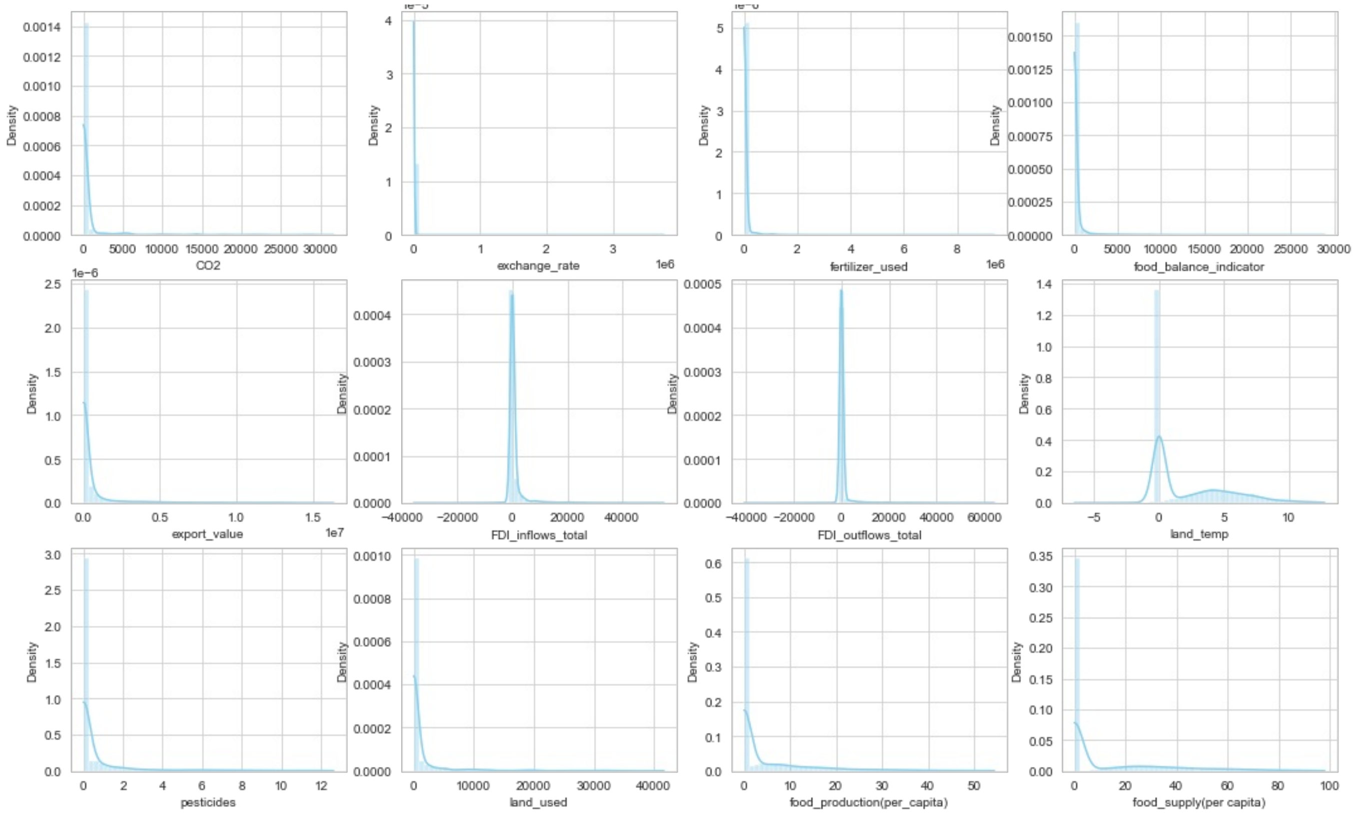


Distribution of Columns

In [240…

```
# Looking for Distribution of cols

n_bins = 50
histplot_hyperparams = {
    'kde':True,
    'alpha':0.4,
    'stat': 'density',
    'bins':n_bins
}
cols=df_filtered_outlier.columns
fig, ax = plt.subplots(4,4, figsize=(18, 15))
ax = ax.flatten()

for i, column in enumerate(cols):
    sns.histplot(
        filtered_df[column], label='Train',
        ax=ax[i], color='skyblue', **histplot_hyperparams
    )
```





As we can see, from boxplots and ditribution plots, It is observed that most of columns are not perfectly normally distributed and most of them are right skewed Also most of the columns have outliers

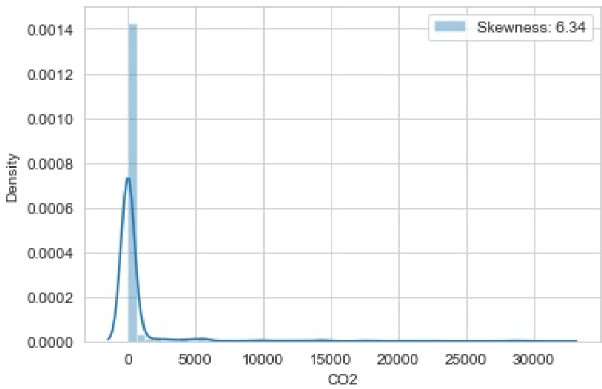
Implementing log for correcting skeness

In [241…

```
t=sns.distplot(filtered_df["CO2"],label="Skewness: %.2f"%(filtered_df["CO2"].skew()) )
t.legend()
```

Out[241…

```
<matplotlib.legend.Legend at 0x7f875e37c4c0>
```

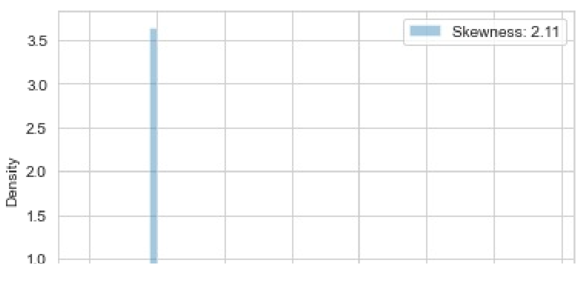


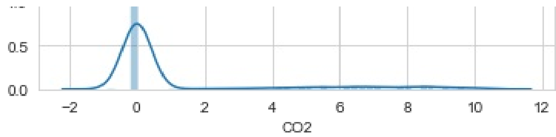
In [242…

```
# after log-transform

Log_Ave = filtered_df["CO2"].map(lambda i: np.log(i) if i > 0 else 0)
t=sns.distplot(Log_Ave,label="Skewness: %.2f"%(Log_Ave.skew()) )
t.legend()
```

Out[242…

```
<matplotlib.legend.Legend at 0x7f875af2b490>
```





here, skewness removed from 6.02 to 1.95

In [243...
```
filtered_df_skew2 = filtered_df.copy()
```

In [244...
```
for col in filtered_df.columns:
    if filtered_df[col].dtype == 'float64':
        filtered_df_skew2[col] = filtered_df_skew2[col].map(lambda i: np.log(i) if i > 0 else 0)
```

In [245...
```
filtered_df_skew2.head()
```

Out[245...

	Area Code (M49)	Year	yield	food_price_inflation	CO2	exchange_rate	fertilizer_used	food_balance_indicator	export_value	FDI_inflows_total	FDI
0	4	2000	12.166802	0.000000	0.0	10.765482	0.0	0.0	10.344320	-1.771957	
1	4	2001	12.176201	5.032842	0.0	10.768485	0.0	0.0	10.207658	-0.385662	
2	4	2002	12.202837	5.389319	0.0	8.289516	0.0	0.0	10.346666	3.912023	
3	4	2003	12.246672	5.131241	0.0	3.886967	0.0	0.0	10.770840	4.056989	
4	4	2004	12.808277	5.129106	0.0	3.867973	0.0	0.0	10.792058	5.230574	

In [246...
```
# # Looking for Distribution of cols

# n_bins = 50
# histplot_hyperparams = {
#     'kde':True,
#     'alpha':0.4,
#     'stat': 'density',
#     'bins':n_bins
# }
# cols=['Area Code (M49)', 'Year', 'Yield', 'CO2', 'exchange_rate',
#        'Fertilizer', 'food_balance_export', 'Export_Value',
#        'Total FDI inflows', 'Total FDI outflows', 'temp_change', 'pesticides',
#        'cropland_use']
# fig, ax = plt.subplots(4,4, figsize=(18, 15))
# ax = ax.flatten()

# for i, column in enumerate(cols):
#     sns.histplot(
#         filtered_df_skew[column], label='Train',
#         ax=ax[i], color='blue', **histplot_hyperparams
#     )
```

For correcting skewness of the data, I will use Log Transform for correcting skewness and for handling outlier I use Z score.

In [247...
```
filtered_df_skew2.shape
```

Out[247...
```
(8506, 16)
```

In [248...
```
filtered_df_skew2.isnull().sum() # checking null values
```

Out[248...
```
Area Code (M49)              0
Year                         0
yield                        0
food_price_inflation         0
CO2                          0
exchange_rate                0
fertilizer_used              0
food_balance_indicator       0
export_value                 0
FDI_inflows_total            0
FDI_outflows_total           0
land_temp                    0
pesticides                   0
land_used                    0
food_production(per_capita)  0
food_supply(per capita)      0
dtype: int64
```

Data Splitting and Normalisation

In [249…
```
# Define test years
test_years = [2020, 2021, 2022] #as no data of export value in 2023

test_df = filtered_df_skew2[filtered_df_skew2['Year'].isin(test_years)]
```

In [250…
```
 # Define test years
train_years = [2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013,2014,2015, 201(

# Filter the DataFrame for training and testing
train_df = filtered_df_skew2[filtered_df_skew2['Year'].isin(train_years)]
```

In [251…
```
from sklearn.preprocessing import RobustScaler
```

In [252…
```
X = train_df.drop(columns=['export_value'])
y = train_df['export_value']

# Displaying the shapes of the training set
print("Training set shape (X_train, y_train):", X.shape, y.shape)
```

```
Training set shape (X_train, y_train): (3910, 15) (3910,)
```

Feature Selection using SelectKBest

In [253…
```
from sklearn.feature_selection import SelectKBest, f_regression

# Use SelectKBest with f_regression to select the top 10 features based on regression scores
selector = SelectKBest(score_func=f_regression, k=10)
selector.fit(X, y)

# Get the scores of each feature
feature_scores = selector.scores_

# Create a DataFrame to store the feature names and their scores
feature_scores_df = pd.DataFrame({'Feature': X.columns, 'Score': feature_scores})

# Sort the features by their scores in descending order
top_features_df = feature_scores_df.sort_values(by='Score', ascending=False).head(10)

# Print the top 10 features and their scores
print("Top 10 Features:")
print(top_features_df)
```

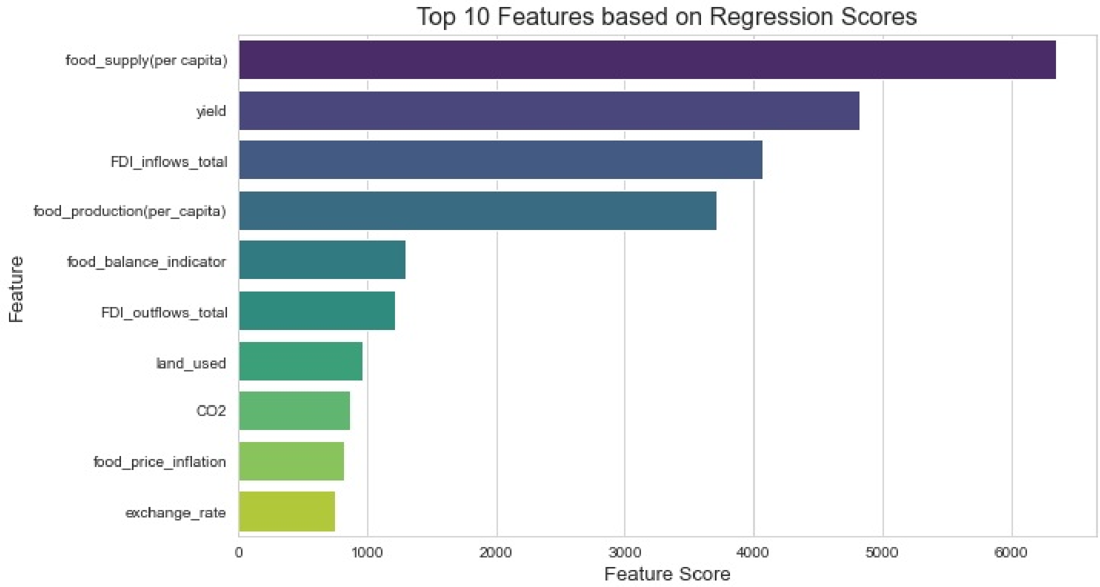
```
Top 10 Features:
                       Feature        Score
14      food_supply(per capita)  6347.515248
2                        yield  4818.435786
8             FDI_inflows_total  4063.243950
13  food_production(per_capita)  3709.037643
7        food_balance_indicator  1293.466630
9            FDI_outflows_total  1214.400056
12                   land_used   963.801221
4                          CO2   871.949158
3          food_price_inflation   820.053137
5                exchange_rate   745.247003
```

In [254…
```
X.columns
```

Out[254…
```
Index(['Area Code (M49)', 'Year', 'yield', 'food_price_inflation', 'CO2',
       'exchange_rate', 'fertilizer_used', 'food_balance_indicator',
       'FDI_inflows_total', 'FDI_outflows_total', 'land_temp', 'pesticides',
       'land_used', 'food_production(per_capita)', 'food_supply(per capita)'],
      dtype='object')
```

In [255…
```
sns.set_style("whitegrid")

# Create the bar plot
plt.figure(figsize=(10, 6))
sns.barplot(x='Score', y='Feature', data=top_features_df, palette='viridis')
plt.xlabel('Feature Score', fontsize=13)
plt.ylabel('Feature', fontsize=13)
```

```
plt.title('Top 10 Features based on Regression Scores', fontsize=16)
plt.show()
```



In [256…

```
# X = X[['Area Code (M49)', 'Year', 'food_supply(per capita)', 'food_production(per_capita)', 'yield', 'food_bala
#        'FDI_outflows_total', 'land_temp', 'land_used']]
X = X[['Area Code (M49)', 'Year','food_supply(per capita)', 'food_production(per_capita)', 'yield', 'food_balance
       'FDI_outflows_total', 'land_used']] #not taking land_temp, exchange_rate, CO2, land_used
```

In [257…

```
from sklearn.model_selection import train_test_split

X_train_val, X_test, y_train_val, y_test = train_test_split(X, y, test_size=0.2, random_state=42)

# Split the training and validation data into 75% training and 25% validation
X_train, X_val, y_train, y_val = train_test_split(X_train_val, y_train_val, test_size=0.25, random_state=42)

# Display the shapes of the training, validation, and testing sets
print("Training set shape (X_train, y_train):", X_train.shape, y_train.shape)
print("Validation set shape (X_val, y_val):", X_val.shape, y_val.shape)
print("Testing set shape (X_test, y_test):", X_test.shape, y_test.shape)
```

```
Training set shape (X_train, y_train): (2346, 9) (2346,)
Validation set shape (X_val, y_val): (782, 9) (782,)
Testing set shape (X_test, y_test): (782, 9) (782,)
```

Data Scaling using RobustScaler

In [258…

```
from sklearn.preprocessing import RobustScaler

# Initialize the StandardScaler

scaler = RobustScaler()

# Fit the scaler to the training data and transform the training data
X_train_scaled = scaler.fit_transform(X_train)

# Transform the validation and testing data using the same scaler
X_val_scaled = scaler.transform(X_val)
X_test_scaled = scaler.transform(X_test)

# Display the shapes of the scaled training, validation, and testing sets
print("Scaled Training set shape (X_train_scaled):", X_train_scaled.shape)
print("Scaled Validation set shape (X_val_scaled):", X_val_scaled.shape)
print("Scaled Testing set shape (X_test_scaled):", X_test_scaled.shape)
```

```
Scaled Training set shape (X_train_scaled): (2346, 9)
Scaled Validation set shape (X_val_scaled): (782, 9)
Scaled Testing set shape (X_test_scaled): (782, 9)
```

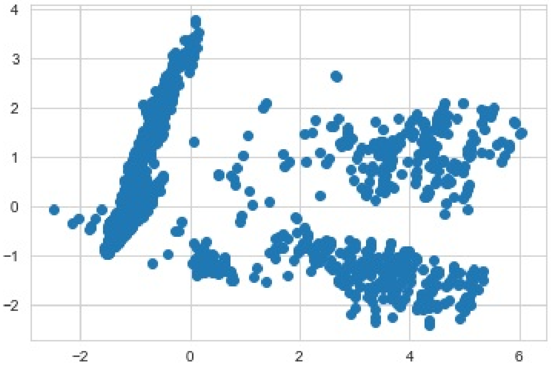
In [ ]:

```

```

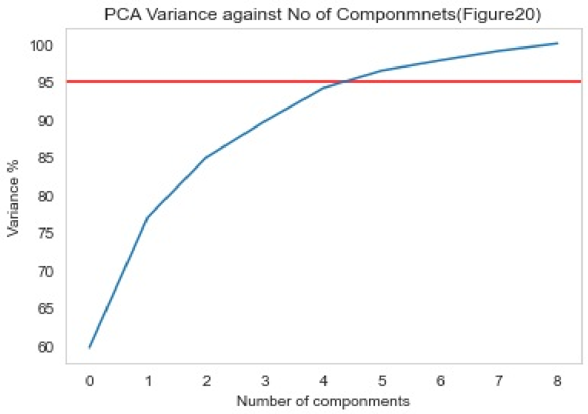
Dimensionality Reduction using PCA

In [259…
```python
from sklearn.decomposition import PCA
```

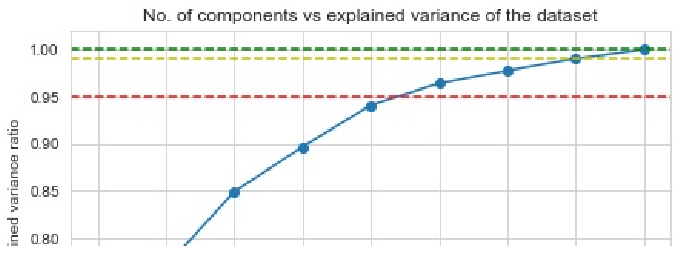
In [260…
```python
#Checking to see if dataset is linearly separable or not
pca = PCA(n_components=2)
X_2PCA_plot = pca.fit_transform(X_train_scaled)
plt.scatter(X_2PCA_plot[:,0], X_2PCA_plot[:,1])
plt.show()
```

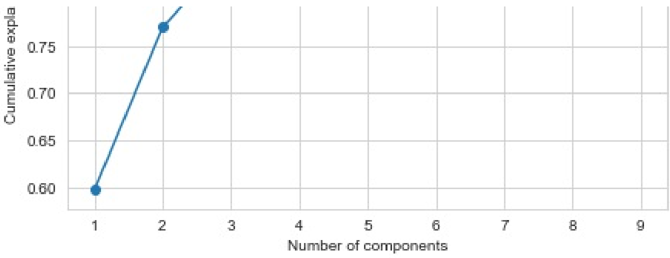


In [261…
```python
pca = PCA()
pca.fit_transform(X_train_scaled)
var= pca.explained_variance_ratio_
var1=np.cumsum(np.round(pca.explained_variance_ratio_, decimals=4)*100)

plt.title("PCA Variance against No of Componmnets(Figure20)")
plt.ylabel("Variance %")
plt.xlabel("Number of componments")
l = plt.axhline(95, color="red")

plt.plot(var1)
plt.grid()
```



In [262…
```python
# Perform PCA to reduce the dimensionality of the dataset
pca = PCA()
pca.fit(X_train_scaled)

# Calculate the cumulative explained variance ratio
exp_variance_cumsum = np.cumsum(pca.explained_variance_ratio_)

# Plot the explained variance ratio for each principal component
plt.figure(figsize=(7, 5))
plt.plot(range(1, len(exp_variance_cumsum)+1), exp_variance_cumsum, marker='o')
plt.xlabel('Number of components')
plt.ylabel('Cumulative explained variance ratio')
plt.axhline(y=0.95, color='r', linestyle='--')
plt.axhline(y=0.99, color='y', linestyle='--')
plt.axhline(y=1, color='g', linestyle='--')
plt.xticks(range(1, len(exp_variance_cumsum)+1))
plt.title('No. of components vs explained variance of the dataset')
plt.show()
```





In [263…
```
pca=PCA(n_components=6)
X_train_pca=pca.fit_transform(X_train_scaled)
X_val_pca = pca.transform(X_val_scaled)
X_test_pca = pca.transform(X_test_scaled)
```

In [264…
```
X_train_pca.shape
```

Out[264… (2346, 6)

In [265…
```
X_val_pca.shape
```

Out[265… (782, 6)

In [266…
```
X_test_pca.shape
```

Out[266… (782, 6)

Creating MLP Model

In [267…
```
import torch
import torch.nn as nn
import torch.optim as optim
from sklearn.metrics import mean_squared_error
from torch.utils.data import DataLoader, TensorDataset
from torch.optim.lr_scheduler import ReduceLROnPlateau
from sklearn.preprocessing import RobustScaler
```

In [268…
```
# Convert NumPy arrays to PyTorch tensors
X_train_tensor = torch.tensor(X_train_scaled, dtype=torch.float32)
y_train_tensor = torch.tensor(y_train.values, dtype=torch.float32)
X_val_tensor = torch.tensor(X_val_scaled, dtype=torch.float32)
y_val_tensor = torch.tensor(y_val.values, dtype=torch.float32)
X_test_tensor = torch.tensor(X_test_scaled, dtype=torch.float32)
```

In [269…
```
X_train_tensor_pca = torch.tensor(X_train_pca, dtype=torch.float32)
X_val_tensor_pca = torch.tensor(X_val_pca, dtype=torch.float32)
X_test_tensor_pca = torch.tensor(X_test_pca, dtype=torch.float32)
```

In [270…
```
X_train_tensor_pca.shape
```

Out[270… torch.Size([2346, 6])

In [271…
```
X_val_tensor_pca.shape
```

Out[271… torch.Size([782, 6])

In [272…
```
X_test_tensor_pca.shape
```

Out[272… torch.Size([782, 6])

In [305…
```
# Creating DataLoader for training data
train_dataset = TensorDataset(X_train_tensor_pca, y_train_tensor)
train_loader = DataLoader(train_dataset, batch_size=100, shuffle=True)
```

```python
#building MLP model class
class MLP_Model(nn.Module):
    def __init__(self, input_size):
        super(MLP_Model, self).__init__()
        self.fc1 = nn.Linear(input_size, 60)
        self.dropout1 = nn.Dropout(0.5)
        self.fc2 = nn.Linear(60, 150)
        self.dropout2 = nn.Dropout(0.2)
        self.fc3 = nn.Linear(150, 1)

    def forward(self, x):
        x = torch.relu(self.fc1(x))
        x = self.dropout1(x)
        x = torch.relu(self.fc2(x))
        x = self.dropout2(x)
        x = torch.relu(self.fc3(x))
        return x
```

In [274…

```python
# Initialize the model
model = MLP_Model(input_size=X_train_pca.shape[1])

# Define the loss function and optimizer
criterion = nn.MSELoss()
optimizer = optim.Adam(model.parameters(), lr=0.001)

# Learning rate reduction scheduler
scheduler = ReduceLROnPlateau(optimizer, 'min', factor=0.2, patience=5, min_lr=0.0001)

# Training loop
for epoch in range(100):
    model.train()
    for inputs, targets in train_loader:
        optimizer.zero_grad()
        outputs = model(inputs)
        loss = criterion(outputs, targets.unsqueeze(1))
        loss.backward()
        optimizer.step()

    # Evaluate on validation set
    model.eval()
    with torch.no_grad():
        y_val_pred = model(X_val_tensor_pca)
        mse_val = criterion(y_val_pred, y_val_tensor.unsqueeze(1))
        scheduler.step(mse_val)

    if (epoch + 1) % 5 == 0:
        print(f'Epoch [{epoch+1}/100], Validation Loss: {mse_val.item():.4f}')

# Predict on the test set
model.eval()
with torch.no_grad():
    y_test_pred = model(X_test_tensor_pca)

# Convert predictions and targets to NumPy arrays
y_test_pred_np = y_test_pred.numpy().flatten()
y_test_np = y_test.values.flatten()

# Evaluate the model using Mean Squared Error (MSE) on the test set
mse_test = mean_squared_error(y_test_np, y_test_pred_np)
print("Mean Squared Error on Test Set:", mse_test)
```

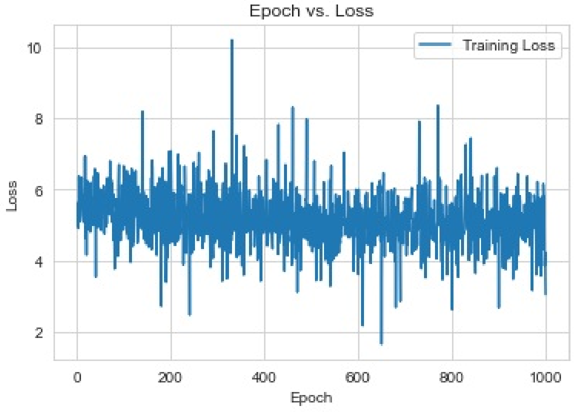
```
Epoch [5/100], Validation Loss: 35.4035
Epoch [10/100], Validation Loss: 10.0500
Epoch [15/100], Validation Loss: 6.3860
Epoch [20/100], Validation Loss: 5.6967
Epoch [25/100], Validation Loss: 5.4894
Epoch [30/100], Validation Loss: 5.4051
Epoch [35/100], Validation Loss: 5.2400
Epoch [40/100], Validation Loss: 5.1339
Epoch [45/100], Validation Loss: 5.0375
Epoch [50/100], Validation Loss: 4.9713
Epoch [55/100], Validation Loss: 4.8978
Epoch [60/100], Validation Loss: 4.7634
Epoch [65/100], Validation Loss: 4.6402
Epoch [70/100], Validation Loss: 4.5505
Epoch [75/100], Validation Loss: 4.4817
Epoch [80/100], Validation Loss: 4.4505
Epoch [85/100], Validation Loss: 4.4036
Epoch [90/100], Validation Loss: 4.3673
Epoch [95/100], Validation Loss: 4.2650
Epoch [100/100], Validation Loss: 4.2627
Mean Squared Error on Test Set: 4.089305287404545
```

In [321…

```python
train_losses = []
```

```python
# Training loop
for epoch in range(100):
    model.train()
    for inputs, targets in train_loader:
        optimizer.zero_grad()
        outputs = model(inputs)
        loss = criterion(outputs, targets.unsqueeze(1))
        loss.backward()
        optimizer.step()

        # Append the training loss to the list
        train_losses.append(loss.item())

    # Evaluate on validation set
    model.eval()
    with torch.no_grad():
        y_val_pred = model(X_val_tensor_pca)
        mse_val = criterion(y_val_pred, y_val_tensor.unsqueeze(1))
        scheduler.step(mse_val)

    if (epoch + 1) % 5 == 0:
        print(f'Epoch [{epoch+1}/100], Validation Loss: {mse_val.item():.4f}')

# Plot epoch vs. training loss
plt.plot(range(1, len(train_losses) + 1), train_losses, label='Training Loss')
plt.xlabel('Epoch')
plt.ylabel('Loss')
plt.title('Epoch vs. Loss')
plt.legend()
plt.show()
```

```
Epoch [5/100], Validation Loss: 4.2520
Epoch [10/100], Validation Loss: 4.1866
Epoch [15/100], Validation Loss: 4.1247
Epoch [20/100], Validation Loss: 4.1658
Epoch [25/100], Validation Loss: 4.0941
Epoch [30/100], Validation Loss: 4.0198
Epoch [35/100], Validation Loss: 4.0512
Epoch [40/100], Validation Loss: 4.1246
Epoch [45/100], Validation Loss: 4.0086
Epoch [50/100], Validation Loss: 3.9827
Epoch [55/100], Validation Loss: 3.9712
Epoch [60/100], Validation Loss: 3.9955
Epoch [65/100], Validation Loss: 3.9773
Epoch [70/100], Validation Loss: 3.9822
Epoch [75/100], Validation Loss: 3.9491
Epoch [80/100], Validation Loss: 3.9677
Epoch [85/100], Validation Loss: 3.9892
Epoch [90/100], Validation Loss: 3.9485
Epoch [95/100], Validation Loss: 3.9608
Epoch [100/100], Validation Loss: 3.9247
```



In [317…

```python
from sklearn.metrics import r2_score

# Evaluating the model using Mean Squared Error (MSE) on the test set
print("Mean Squared Error on Test Set:", mse_test)

mse_val = mean_squared_error(y_val, y_val_pred)
print("Mean Squared Error on Validation Set:", mse_val)

# Converting predictions and targets to NumPy arrays
y_val_pred_np = y_val_pred.numpy().flatten()
y_val_np = y_val.values.flatten()

# Calculating R^2 score
r2 = r2_score(y_test_np, y_test_pred_np)
print("R^2 Score on Test Set:", r2)
```

```python
# Calculating R^2 score on the validation set
r2_val = r2_score(y_val_np, y_val_pred_np)
print("R^2 Score on Validation Set:", r2_val)
```

```
Mean Squared Error on Test Set: 4.089305287404545
Mean Squared Error on Validation Set: 4.2626511456298894
R^2 Score on Test Set: 0.8683023543832229
R^2 Score on Validation Set: 0.8706884203848051
```

In [276…

```python
# Add the year and area code to the predictions
test_df_with_predictions = X_test.copy()
test_df_with_predictions['Predicted Value (USD)'] = y_test_pred.squeeze().tolist()
test_df_with_predictions['Actual Value (USD)'] = y_test

# Add the year and area code to the predictions
test_df_with_predictions = train_df[['Year', 'Area Code (M49)']].merge(test_df_with_predictions, left_index=True,
```

In [277…

```python
test_df_with_predictions.head()
```

Out[277…

	Year_x	Area Code (M49)_x	Area Code (M49)_y	Year_y	food_supply(per capita)	food_production(per_capita)	yield	food_balance_indicator	FDI_inflows_total	FDI_ou
0	2000	4	4	2000	4.060443	0.000000	12.166802	0.000000	-1.771957	
6	2006	4	4	2006	3.784190	2.667228	12.727628	0.000000	5.472271	
8	2008	4	4	2008	3.332205	2.140066	11.948299	0.000000	3.829375	
12	2012	4	4	2012	4.060443	2.251292	12.750723	5.288267	3.710248	
14	2014	4	4	2014	3.970292	2.151762	12.802858	6.021023	3.760625	

In [278…

```python
test_df_with_predictions_grouped_actual = test_df_with_predictions.groupby('Year_x')['Actual Value (USD)'].sum().
test_df_with_predictions_grouped_predicted = test_df_with_predictions.groupby('Year_x')['Predicted Value (USD)'].
```

In [279…

```python
test_df2 = test_df[['Area Code (M49)', 'Year','food_supply(per capita)', 'food_production(per_capita)', 'yield',
       'FDI_outflows_total', 'land_used']]
```

In [280…

```python
test_df2.head()
```

Out[280…

	Area Code (M49)	Year	food_supply(per capita)	food_production(per_capita)	yield	food_balance_indicator	FDI_inflows_total	FDI_outflows_total	land_use
20	4	2020	3.465736	2.151762	13.328061	6.799056	2.562650	3.617074	0.00000
21	4	2021	3.433987	0.000000	12.948498	7.305860	3.025338	3.427221	0.00000
22	4	2022	0.000000	0.000000	12.987714	0.000000	0.000000	0.000000	0.00000
43	8	2020	2.564949	2.001480	14.262294	5.111988	6.975284	4.471942	6.53314
44	8	2021	2.564949	0.000000	14.268835	5.209486	7.111188	4.144521	6.53310

In [281…

```python
# Prepare the test_df by dropping the 'Export Value (USD)' column
X_test_df = test_df2.copy()
```

In [282…

```python
X_test_df.head()
```

Out[282…

	Area Code (M49)	Year	food_supply(per capita)	food_production(per_capita)	yield	food_balance_indicator	FDI_inflows_total	FDI_outflows_total	land_use
20	4	2020	3.465736	2.151762	13.328061	6.799056	2.562650	3.617074	0.00000
21	4	2021	3.433987	0.000000	12.948498	7.305860	3.025338	3.427221	0.00000
22	4	2022	0.000000	0.000000	12.987714	0.000000	0.000000	0.000000	0.00000
43	8	2020	2.564949	2.001480	14.262294	5.111988	6.975284	4.471942	6.53314
44	8	2021	2.564949	0.000000	14.268835	5.209486	7.111188	4.144521	6.53310

In [283…

```python
X_test_df_scaled = scaler.transform(X_test_df)
```

In [284…

```python
X_test_df_scaled.shape
```

Out[284…

```
(592, 9)
```

In [285…
```
# Define and fit PCA on the training data
pca = PCA(n_components=6)
X_test_df_scaled_pca = pca.fit_transform(X_test_df_scaled)

# # Transform the test data using the fitted PCA instance
# X_test_df_scaled_pca = pca.transform(X_test_df_scaled)
```

In [286…
```
X_test_df_scaled_pca.shape
```

Out[286… (592, 6)

In [287…
```
X_test_df_scaled_pca = torch.tensor(X_test_df_scaled_pca, dtype=torch.float32)
```

In [288…
```
model.eval()
with torch.no_grad():
    test_predictions = model(X_test_df_scaled_pca)
```

In [289…
```
test_df_pred = X_test_df.copy()
test_df_pred['Predicted Value (USD)'] = test_predictions.squeeze().tolist()
test_df_pred['Actual Value (USD)'] = test_df['export_value'].values
```

In [290…
```
test_df_pred.head(10)
```

Out[290…

	Area Code (M49)	Year	food_supply(per capita)	food_production(per_capita)	yield	food_balance_indicator	FDI_inflows_total	FDI_outflows_total	land_use
20	4	2020	3.465736	2.151762	13.328061	6.799056	2.562650	3.617074	0.00000
21	4	2021	3.433987	0.000000	12.948498	7.305860	3.025338	3.427221	0.00000
22	4	2022	0.000000	0.000000	12.987714	0.000000	0.000000	0.000000	0.00000
43	8	2020	2.564949	2.001480	14.262294	5.111988	6.975284	4.471942	6.53314
44	8	2021	2.564949	0.000000	14.268835	5.209486	7.111188	4.144521	6.53310
45	8	2022	0.000000	0.000000	14.298386	0.000000	7.268311	5.095437	0.00000
66	12	2020	3.737670	2.014903	13.794938	6.769642	7.041097	2.685819	0.00000
67	12	2021	3.806662	0.000000	13.786243	6.637258	6.768098	0.000000	0.00000
88	24	2020	3.295837	0.993252	12.271078	3.931826	0.000000	4.505510	0.00000
89	24	2021	2.079442	0.000000	12.267083	3.850148	0.000000	0.000000	0.00000

In [291…
```
selected_col=test_df_pred[['Area Code (M49)','Year','Predicted Value (USD)','Actual Value (USD)']]
```

In [292…
```
selected_col.head()
```

Out[292…

	Area Code (M49)	Year	Predicted Value (USD)	Actual Value (USD)
20	4	2020	8.787487	13.453783
21	4	2021	7.826019	13.494983
22	4	2022	8.616978	13.202831
43	8	2020	12.933577	11.644769
44	8	2021	12.779428	11.641084

In [293…
```
#reversing log transformation
for col in selected_col.columns:
    if col not in ['Year', 'Area Code (M49)']:  #excluding categorical cols
        selected_columns1[col] = np.exp(selected_col[col])
```

In [294…
```
selected_col.shape
```

Out[294… (592, 4)

In [295…
```
df_land_use['Area Code (M49)'].nunique() # has most Area Code (M49)
df_land_use = df_land_use[['Area Code (M49)', 'Area']]
```

In [296…
```
df_land_use.drop_duplicates()
```

Out[296…

Area Code (M49)	Area

0	4	Afghanistan
490	8	Albania
974	12	Algeria
1473	16	American Samoa
1872	20	Andorra
...	...	...
96207	732	Western Sahara
96564	887	Yemen
97005	890	Yugoslav SFR
97113	894	Zambia
97554	716	Zimbabwe

247 rows × 2 columns

In [297…

```
df_output = pd.merge(selected_col, df_land_use, on = 'Area Code (M49)')
```

In [298…

```
df_output = df_output[['Area', 'Year', 'Predicted Value (USD)', 'Actual Value (USD)']]
```

In [299…

```
df_output = df_output.drop_duplicates()
```

In [300…

```
def merge_area_code_area(row):
    return f"{row['Area']}-{row['Year']}"

# Apply the function to create the 'index' column
df_output['Index'] = df_output.apply(merge_area_code_area, axis=1)
```

In [301…

```
df_output.head()
```

Out[301…

	Area	Year	Predicted Value (USD)	Actual Value (USD)	Index
0	Afghanistan	2020	6551.747127	696471.98	Afghanistan-2020
490	Afghanistan	2021	2504.938061	725765.72	Afghanistan-2021
980	Afghanistan	2022	5524.663898	541896.88	Afghanistan-2022
1470	Albania	2020	413981.507470	114093.03	Albania-2020
1954	Albania	2021	354841.868503	113673.36	Albania-2021

In [302…

```
df_output = df_output[['Index', 'Actual Value (USD)', 'Predicted Value (USD)']]
```

In [303…

```
df_output.head()
```

Out[303…

	Index	Actual Value (USD)	Predicted Value (USD)
0	Afghanistan-2020	696471.98	6551.747127
490	Afghanistan-2021	725765.72	2504.938061
980	Afghanistan-2022	541896.88	5524.663898
1470	Albania-2020	114093.03	413981.507470
1954	Albania-2021	113673.36	354841.868503

In [304…

```
df_output.to_csv('output.csv', index = False)
```

In [ ]:

In [ ]: