# Data Mining Project - Sustainability Around The World


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## Exploratory Data Analysis

In [1]:

```
#Importing libraries
import warnings
warnings.filterwarnings('ignore')
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
import numpy as np
import scipy.stats as stats
import statsmodels.api as sm
```

In [2]:

```
#Reading Dataset
epi2022 = pd.read_csv('epi2022.csv')
EPI = epi2022[['country', 'region','EPI.new',
               'PCC.new','CCH.new','CDA.new','CHA.new','FGA.new', 'NDA.new','BCA.ne
               'HLT.new','AIR.new','HAD.new','PMD.new','OZD.new','NOE.new','SOE.new
               'H2O.new','USD.new','UWD.new',
               'HMT.new','PBD.new',
               'WMG.new','MSW.new','REC.new','OCP.new',
               'ECO.new','BDH.new','TBN.new','TBG.new','MPA.new','PAR.new','SHI.new
               'ECS.new','TCL.new','GRL.new','WTL.new',
               'FSH.new','FSS.new','RMS.new','FTD.new',
               'ACD.new','SDA.new','NXA.new',
               'AGR.new','SPU.new','SNM.new',
               'WRS.new','WWT.new'
               ]]
#Changing column names for ease
EPI.columns = ['Country', 'Region', 'EPI',
               'PCC','CCH','CDA','CHA','FGA', 'NDA','BCA','GHN','LCB','GIB','GHP',
               'HLT','AIR','HAD','PMD','OZD','NOE','SOE','COE','VOE',
               'H2O','USD','UWD',
               'HMT','PBD',
               'WMG','MSW','REC','OCP',
               'ECO','BDH','TBN','TBG','MPA','PAR','SHI','SPI','BHV',
               'ECS','TCL','GRL','WTL',
               'FSH','FSS','RMS','FTD',
               'ACD','SDA','NXA',
               'AGR','SPU','SNM',
               'WRS','WWT']
EPI.head() #Displaying EPI dataset
```

Out[2]:

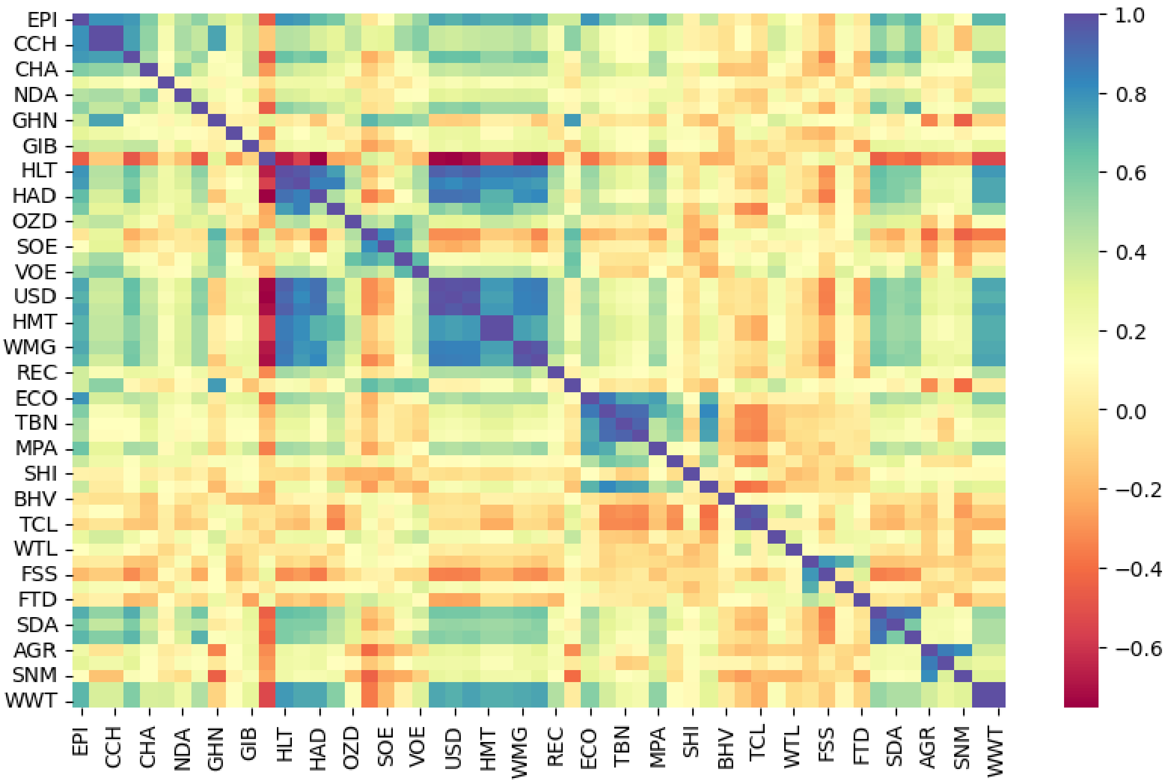
| | Country | Region | EPI | PCC | CCH | CDA | CHA | FGA | NDA | BCA | ... | RMS | FTD | ACD | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **0** | Afghanistan | Southern Asia | 43.6 | 65.6 | 65.6 | 83.9 | 50.2 | 54.5 | 63.7 | 42.9 | ... | 28.2 | 0.6 | 35.5 | |
| **1** | Albania | Eastern Europe | 47.1 | 52.5 | 52.5 | 42.3 | 50.1 | 59.4 | 76.9 | 100.0 | ... | 30.2 | 0.8 | 90.2 | 1 |
| **2** | Algeria | Greater Middle East | 29.6 | 20.9 | 20.9 | 18.8 | 36.1 | 76.5 | 46.3 | 63.9 | ... | 12.4 | 9.3 | 70.8 | |
| **3** | Angola | Sub-Saharan Africa | 30.5 | 37.7 | 37.7 | 39.0 | 49.7 | 57.7 | 70.4 | 51.8 | ... | 17.6 | 7.9 | 50.5 | |
| **4** | Antigua and Barbuda | Latin America & Caribbean | 52.4 | 60.2 | 60.2 | 37.4 | 50.2 | 60.9 | 79.0 | 69.0 | ... | 9.0 | 6.4 | 93.2 | 1 |

5 rows × 57 columns

In [3]:

```
#Heatmap for EPI Dataset
plt.figure(figsize = (10,6))
sns.heatmap(EPI.corr(), cmap="Spectral")
```

Out[3]: <AxesSubplot:>




In [4]:

```
#EPI attributes just for USA
USA = EPI.iloc[172:173]
USA
```

Out[4]:

| | Country | Region | EPI | PCC | CCH | CDA | CHA | FGA | NDA | BCA | ... | RMS | FTD | ACD | SD. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **172** | United States of America | Global West | 51.1 | 37.2 | 37.2 | 57.8 | 53.3 | 81.7 | 73.6 | 100.0 | ... | 13.0 | 10.0 | 100.0 | 100. |

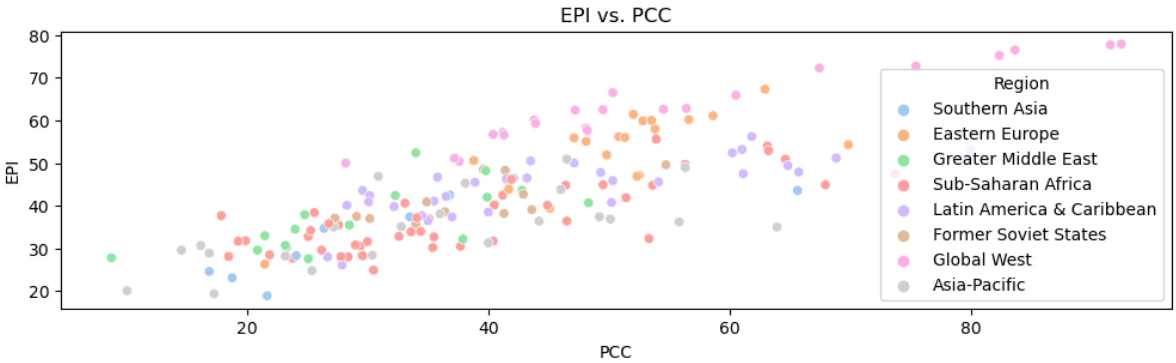
1 rows × 57 columns

In [5]:
```
#Checking Original vs Expected Data
usa_pcc = USA.PCC
usa_hlt = USA.HLT
usa_eco = USA.ECO
epi_expected = 0.38*usa_pcc + 0.20*usa_hlt + 0.42*usa_eco
print('Expected EPI is:', epi_expected)
epi_original = USA.EPI
print('Original EPI is', epi_original)
```

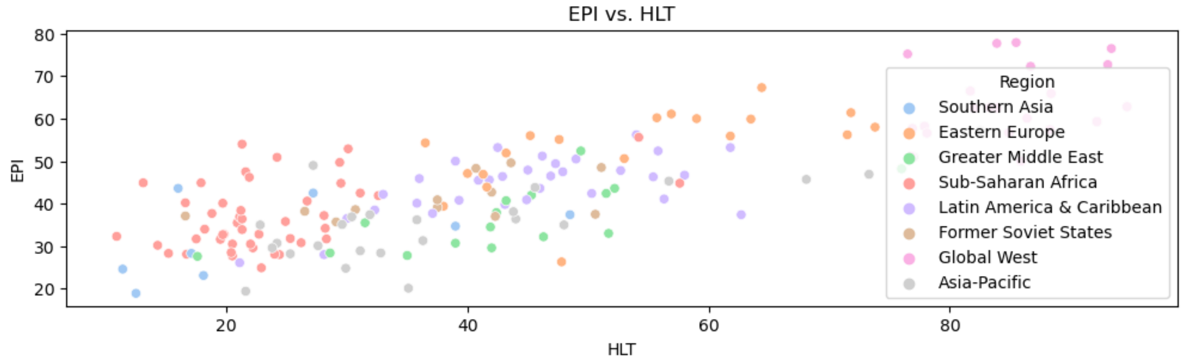
```
Expected EPI is: 172    51.084
dtype: float64
Original EPI is 172    51.1
Name: EPI, dtype: float64
```

Scatter Plots for EPI vs PCC, HLT and ECO

In [6]:
```
#EPI vs PCC
plt.figure(figsize=(12,3))
sns.scatterplot(y=EPI.EPI, x=EPI.PCC, hue=EPI.Region, palette = 'pastel')
plt.ylabel('EPI')
plt.xlabel('PCC')
plt.title("EPI vs. PCC")
plt.show()
```

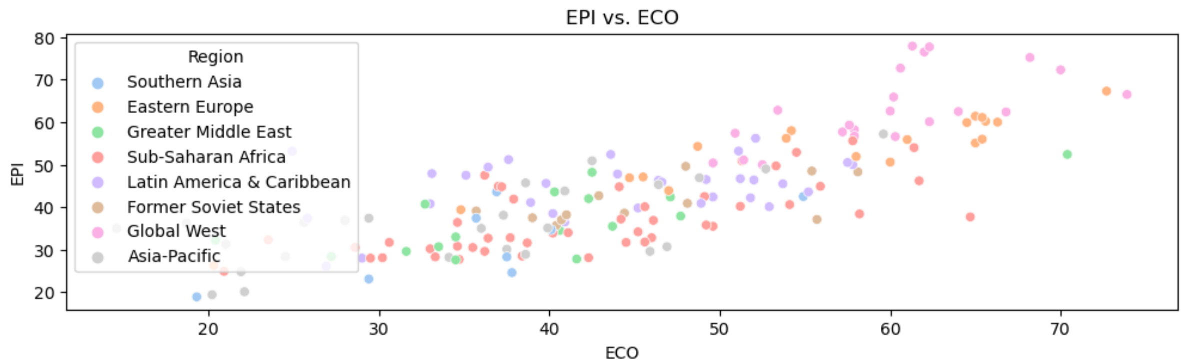



In [7]:
```
#EPI vs HLT
plt.figure(figsize=(12,3))
sns.scatterplot(y=EPI.EPI, x=EPI.HLT, hue=EPI.Region, palette = 'pastel')
plt.ylabel('EPI')
plt.xlabel('HLT')
plt.title("EPI vs. HLT")
plt.show()
```



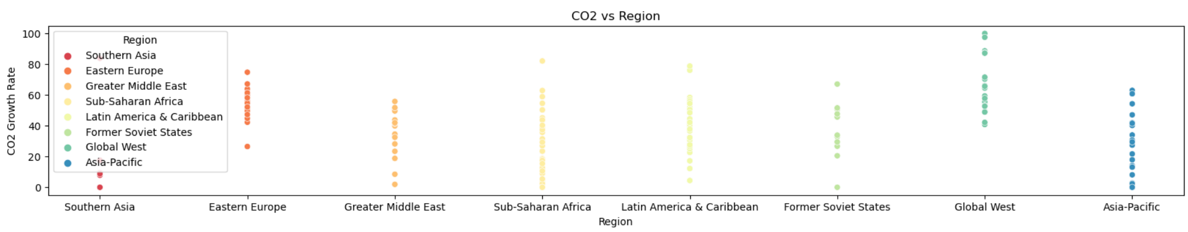

In [8]:

```
# EPI vs ECO
plt.figure(figsize=(12,3))
sns.scatterplot(y=EPI.EPI, x=EPI.ECO, hue=EPI.Region, palette = 'pastel')
plt.ylabel('EPI')
plt.xlabel('ECO')
plt.title("EPI vs. ECO")
plt.show()
```




In [9]:

```
#CO2 growth rate vs Region
plt.figure(figsize=(20,3))
sns.scatterplot(y=EPI.CDA, x=EPI.Region, hue=EPI.Region, palette = 'Spectral')
plt.ylabel('CO2 Growth Rate')
plt.xlabel('Region')
plt.title("CO2 vs Region")
plt.show()
```




In [10]:

```
#Binning
World = EPI
World['Binned'] = pd.cut(World['EPI'], bins=7, labels=["Very Poor", "Poor", "Below
World.sort_values(by=['Binned','EPI'])
```

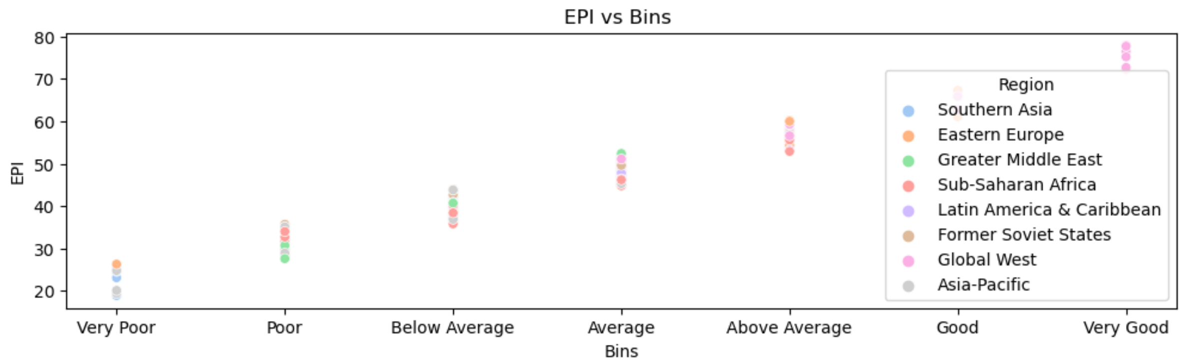
Out[10]:

| | Country | Region | EPI | PCC | CCH | CDA | CHA | FGA | NDA | BCA | ... | FTD | ACD | SD. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **74** | India | Southern Asia | 18.9 | 21.7 | 21.7 | 17.6 | 48.0 | 64.2 | 60.7 | 100.0 | ... | 3.5 | 54.4 | 51. |
| **112** | Myanmar | Asia-Pacific | 19.4 | 17.3 | 17.3 | 0.0 | 30.9 | 69.0 | 22.4 | 31.4 | ... | 4.3 | 0.0 | 0. |
| **177** | Viet Nam | Asia-Pacific | 20.1 | 10.1 | 10.1 | 0.0 | 50.8 | NaN | 40.1 | 0.0 | ... | 2.4 | 19.3 | 26. |
| **12** | Bangladesh | Southern Asia | 23.1 | 18.8 | 18.8 | 9.4 | 37.7 | NaN | 56.0 | 46.0 | ... | 11.3 | 25.8 | 12. |
| **123** | Pakistan | Southern Asia | 24.6 | 16.9 | 16.9 | 8.8 | 24.5 | 76.3 | 31.2 | 41.1 | ... | NaN | 48.0 | 42. |
| **...** | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | . |
| **155** | Sweden | Global West | 72.7 | 75.4 | 75.4 | 87.2 | 68.5 | 96.0 | 100.0 | 100.0 | ... | 8.9 | 100.0 | 100. |
| **101** | Malta | Global West | 75.2 | 82.3 | 82.3 | 87.5 | 81.5 | 58.1 | 100.0 | 100.0 | ... | 0.5 | 100.0 | 100. |
| **57** | Finland | Global West | 76.5 | 83.6 | 83.6 | 88.7 | 72.5 | 92.0 | 95.5 | 100.0 | ... | NaN | 100.0 | 100. |
| **171** | United Kingdom | Global West | 77.7 | 91.5 | 91.5 | 97.5 | 71.8 | 82.4 | 71.0 | 100.0 | ... | 9.2 | 100.0 | 100. |
| **44** | Denmark | Global West | 77.9 | 92.4 | 92.4 | 100.0 | 57.5 | 100.0 | 67.0 | 100.0 | ... | 9.5 | 100.0 | 100. |

180 rows × 58 columns

In [11]:

```
# EPI vs Bins
plt.figure(figsize=(12,3))
sns.scatterplot(y=World.EPI, x=World.Binned, hue=World.Region , palette = 'pastel'
plt.ylabel('EPI')
plt.xlabel('Bins')
plt.title("EPI vs Bins ")
plt.show()
```




In [12]:

```
#Climate Change Mitigation
PCC = EPI[['Country', 'Region', 'EPI',
        'PCC','CCH','CDA','CHA','FGA', 'NDA','BCA','GHN','LCB','GIB','GHP']]
PCC
```

Out[12]:

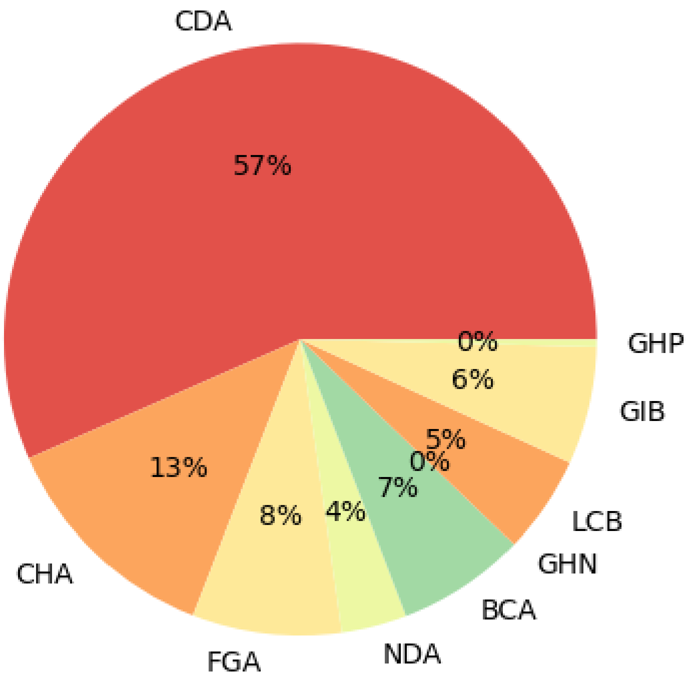
| | Country | Region | EPI | PCC | CCH | CDA | CHA | FGA | NDA | BCA | GHN | LCB | GIB |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **0** | Afghanistan | Southern Asia | 43.6 | 65.6 | 65.6 | 83.9 | 50.2 | 54.5 | 63.7 | 42.9 | 45.3 | 100.0 | 77.5 |
| **1** | Albania | Eastern Europe | 47.1 | 52.5 | 52.5 | 42.3 | 50.1 | 59.4 | 76.9 | 100.0 | 53.9 | 87.3 | 49.6 |
| **2** | Algeria | Greater Middle East | 29.6 | 20.9 | 20.9 | 18.8 | 36.1 | 76.5 | 46.3 | 63.9 | 8.6 | 13.3 | 23.1 |
| **3** | Angola | Sub-Saharan Africa | 30.5 | 37.7 | 37.7 | 39.0 | 49.7 | 57.7 | 70.4 | 51.8 | 26.4 | 37.9 | 45.2 |
| **4** | Antigua and Barbuda | Latin America & Caribbean | 52.4 | 60.2 | 60.2 | 37.4 | 50.2 | 60.9 | 79.0 | 69.0 | 83.5 | 88.6 | 48.0 |
| **...** | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| **175** | Vanuatu | Asia-Pacific | 36.9 | 50.1 | 50.1 | 21.7 | 38.4 | NaN | 61.5 | 85.2 | 80.5 | 24.3 | 41.8 |
| **176** | Venezuela | Latin America & Caribbean | 46.4 | 42.1 | 42.1 | 54.5 | 50.8 | 74.5 | 72.9 | 100.0 | 22.3 | 51.2 | 0.0 |
| **177** | Viet Nam | Asia-Pacific | 20.1 | 10.1 | 10.1 | 0.0 | 50.8 | NaN | 40.1 | 0.0 | 2.5 | 12.5 | 45.9 |
| **178** | Zambia | Sub-Saharan Africa | 38.4 | 25.6 | 25.6 | 0.0 | 39.7 | 59.4 | 68.9 | 32.0 | 33.7 | 39.1 | 53.8 |
| **179** | Zimbabwe | Sub-Saharan Africa | 46.2 | 41.9 | 41.9 | 29.3 | 55.1 | NaN | 100.0 | 54.5 | 40.8 | 57.4 | 63.7 |

180 rows × 14 columns

In [13]:

```
#USA
USA_PCC = PCC.iloc[172:173]
print(USA_PCC)
#Pie Chart with factors in %  responsible for air quality in USA
pcc_data = [0.363*USA_PCC.CDA, 0.087*USA_PCC.CHA, 0.037*USA_PCC.FGA, 0.018*USA_PCC
            0.363*0, 0.039*USA_PCC.LCB, 0.039*USA_PCC.GIB, 0.026*USA_PCC.GHP]
pcc_labels = ['CDA', 'CHA', 'FGA', 'NDA','BCA',
              'GHN','LCB','GIB','GHP']
pcc_colors = sns.color_palette('Spectral')[0:5]
plt.pie(pcc_data, labels=pcc_labels,colors = pcc_colors, autopct = '%0.0f%%')
plt.show()
```

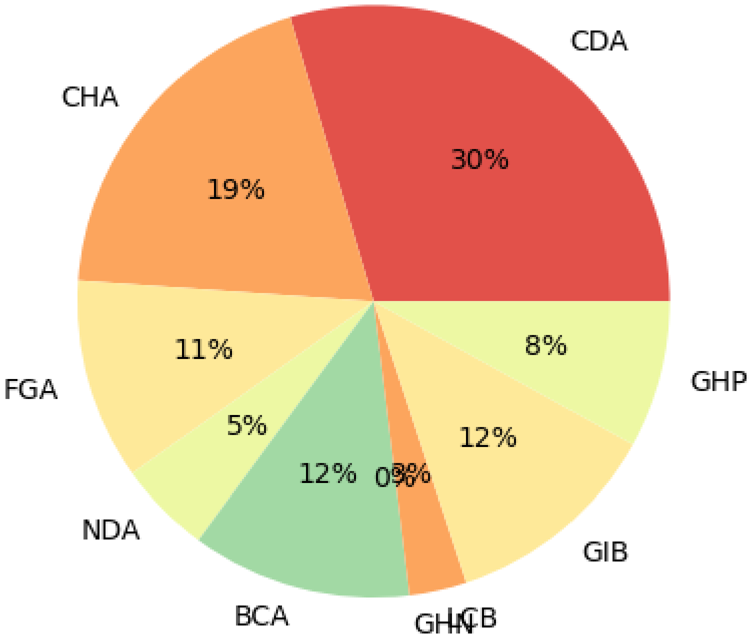
```
                      Country        Region   EPI   PCC   CCH   CDA   CHA  \
172  United States of America  Global West  51.1  37.2  37.2  57.8  53.3

      FGA   NDA    BCA  GHN   LCB   GIB  GHP
172  81.7  73.6  100.0  0.0  50.7  61.2  5.7
```




In [14]:

```
#India
IND_PCC = PCC.iloc[74:75]
print(IND_PCC)
#Pie Chart with factors in %  responsible for air quality in India
ind_pcc_data = [0.363*IND_PCC.CDA, 0.087*IND_PCC.CHA, 0.037*IND_PCC.FGA, 0.018*IND_
            0.363*0, 0.039*IND_PCC.LCB, 0.039*IND_PCC.GIB, 0.026*IND_PCC.GHP]
ind_pcc_labels = ['CDA', 'CHA', 'FGA', 'NDA','BCA',
              'GHN','LCB','GIB','GHP']
ind_pcc_colors = sns.color_palette('Spectral')[0:5]
plt.pie(ind_pcc_data, labels=ind_pcc_labels,colors = ind_pcc_colors, autopct = '%0
plt.show()
```

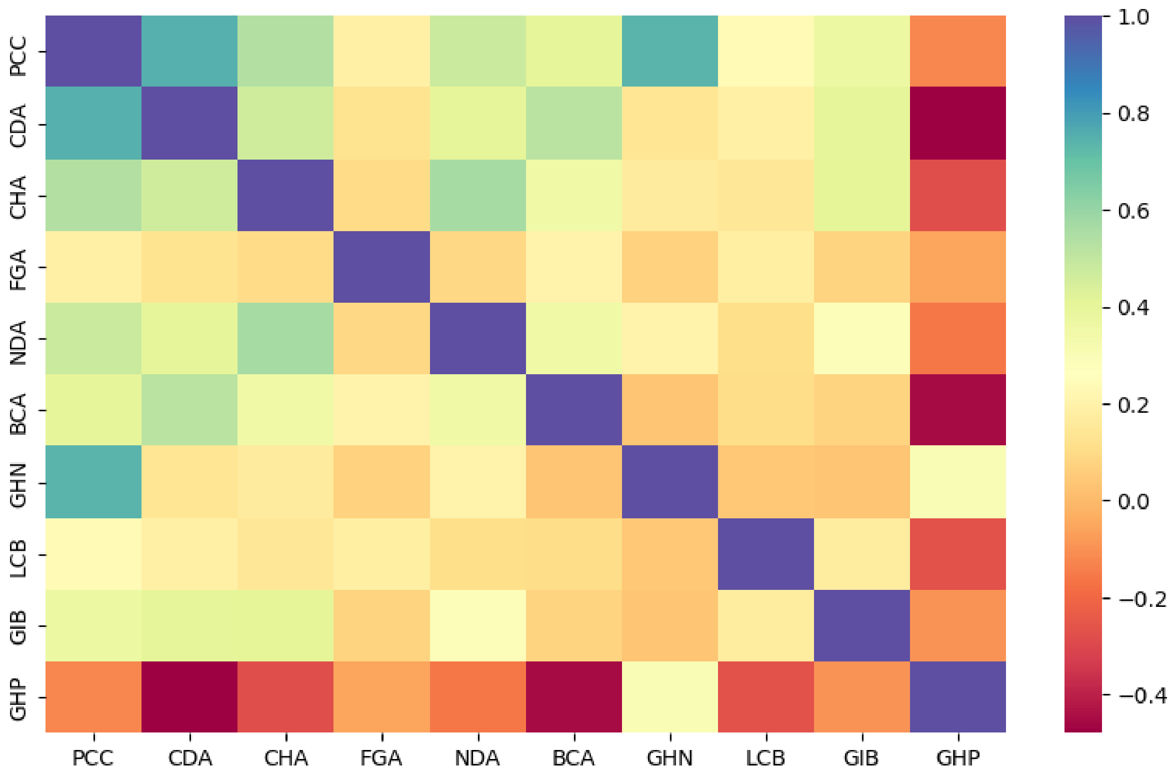
```
   Country         Region   EPI   PCC   CCH   CDA   CHA   FGA   NDA    BCA  \
74   India  Southern Asia  18.9  21.7  21.7  17.6  48.0  64.2  60.7  100.0

    GHN   LCB   GIB   GHP
74  0.0  17.4  65.9  66.8
```




```
In [15]: PCC_cor = EPI[['PCC','CDA','CHA','FGA', 'NDA','BCA','GHN','LCB','GIB','GHP']]
```

```
In [16]: #Heatmap
plt.figure(figsize = (10,6))
sns.heatmap(PCC_cor.corr(), cmap="Spectral")
```

```
Out[16]: <AxesSubplot:>
```




It is evident that CO2 Growth Rate (CDA) is the biggest factor in Climate Change. In order to mitigate climate change CO2 has to be reduced. CO2 growth rate can be defined as the average annual rate of increase or decrease in raw carbon dioxide emissions over the years

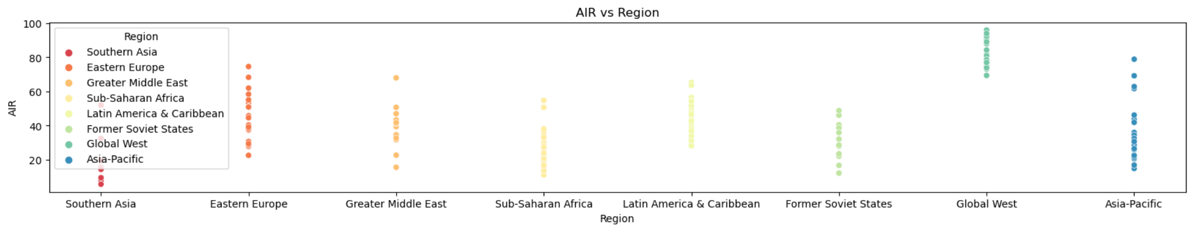
In [17]:
```
#Environmental Health
HLT = EPI[['Country', 'Region', 'EPI',
           'HLT', 'AIR' ,'H2O', 'HMT','WMG']]

HLT
```

Out[17]:

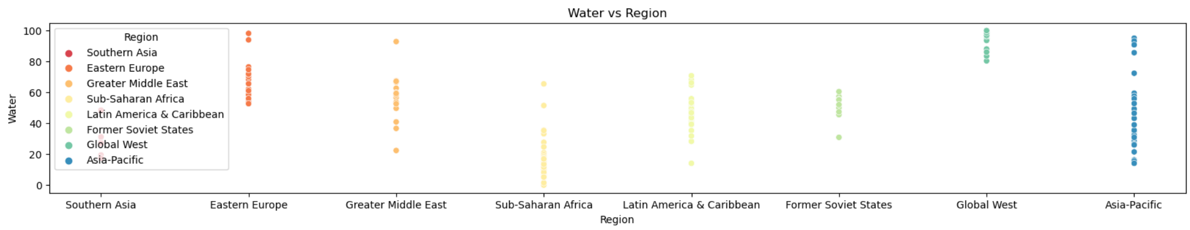
| | Country | Region | EPI | HLT | AIR | H2O | HMT | WMG |
|---|---|---|---|---|---|---|---|---|
| 0 | Afghanistan | Southern Asia | 43.6 | 16.0 | 15.5 | 28.1 | 0.0 | 4.4 |
| 1 | Albania | Eastern Europe | 47.1 | 40.0 | 37.5 | 54.1 | 45.5 | 13.4 |
| 2 | Algeria | Greater Middle East | 29.6 | 42.0 | 39.4 | 53.3 | 38.3 | 32.0 |
| 3 | Angola | Sub-Saharan Africa | 30.5 | 20.5 | 23.1 | 12.8 | 36.7 | 9.6 |
| 4 | Antigua and Barbuda | Latin America & Caribbean | 52.4 | 55.8 | 56.5 | 50.1 | 59.8 | 62.3 |
| ... | ... | ... | ... | ... | ... | ... | ... | ... |
| 175 | Vanuatu | Asia-Pacific | 36.9 | 30.4 | 30.7 | 21.5 | 44.9 | 36.5 |
| 176 | Venezuela | Latin America & Caribbean | 46.4 | 42.9 | 46.7 | 46.8 | 42.5 | 12.1 |
| 177 | Viet Nam | Asia-Pacific | 20.1 | 35.1 | 26.5 | 52.8 | 47.1 | 25.6 |
| 178 | Zambia | Sub-Saharan Africa | 38.4 | 21.2 | 23.6 | 13.5 | 41.7 | 6.9 |
| 179 | Zimbabwe | Sub-Saharan Africa | 46.2 | 21.9 | 23.9 | 16.9 | 32.1 | 13.3 |

180 rows × 8 columns

In [18]:
```
#Air Quality vs Region (Each dot represents a country in that region)
plt.figure(figsize=(20,3))
sns.scatterplot(y=HLT.AIR, x=HLT.Region , hue=EPI.Region, palette = 'Spectral')
plt.ylabel('AIR')
plt.xlabel('Region')
plt.title("AIR vs Region")
plt.show()
```




In [19]:
```
#Water Quality vs Region (Each dot represents a country in that region)
plt.figure(figsize=(20,3))
sns.scatterplot(y=HLT.H2O, x=HLT.Region , hue=EPI.Region, palette = 'Spectral')
plt.ylabel('Water')
plt.xlabel('Region')
plt.title("Water vs Region")
plt.show()
```



In [20]:
```
#Air Quality and its components
AIR = epi2022[['country','AIR.new','HAD.new','PMD.new','OZD.new','NOE.new','SOE.ne
AIR.columns = ['Country','AIR','HAD','PMD','OZD','NOE','SOE','COE','VOE']
AIR
```

Out[20]:

| | Country | AIR | HAD | PMD | OZD | NOE | SOE | COE | VOE |
|---|---|---|---|---|---|---|---|---|---|
| **0** | Afghanistan | 15.5 | 7.4 | 16.0 | 18.4 | 37.8 | 61.2 | 42.7 | 37.5 |
| **1** | Albania | 37.5 | 34.5 | 36.7 | 63.7 | 29.5 | 43.3 | 61.5 | 46.9 |
| **2** | Algeria | 39.4 | 78.4 | 12.1 | 35.6 | 8.2 | 27.6 | 39.9 | 30.7 |
| **3** | Angola | 23.1 | 17.9 | 24.0 | 36.8 | 32.4 | 60.2 | 30.3 | 8.3 |
| **4** | Antigua and Barbuda | 56.5 | 69.3 | 37.1 | 100.0 | 77.2 | 62.2 | 91.6 | 91.4 |
| **...** | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| **175** | Vanuatu | 30.7 | 6.1 | 34.5 | 62.7 | 100.0 | 82.8 | 100.0 | 71.2 |
| **176** | Venezuela | 46.7 | 74.4 | 25.1 | 59.2 | 30.5 | 60.6 | 58.2 | 10.5 |
| **177** | Viet Nam | 26.5 | 24.9 | 28.4 | 41.3 | 14.9 | 33.2 | 8.4 | 17.6 |
| **178** | Zambia | 23.6 | 12.6 | 28.6 | 36.4 | 37.6 | 43.9 | 46.6 | 12.8 |
| **179** | Zimbabwe | 23.9 | 10.4 | 30.1 | 43.5 | 34.8 | 55.0 | 45.5 | 17.7 |

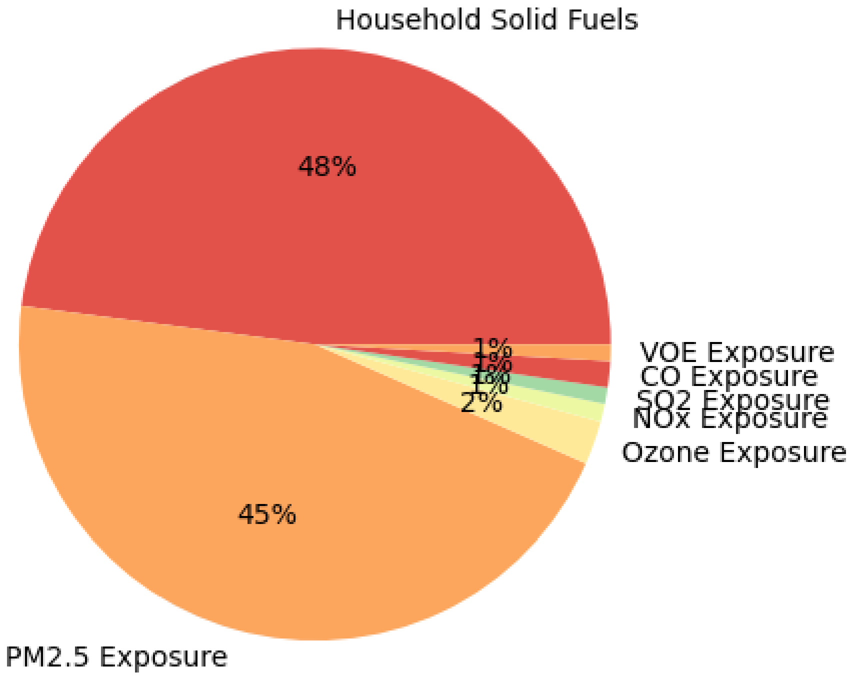
180 rows × 9 columns

In [21]:
```
#Quality of Air in USA
USA_AIR = AIR.iloc[172:173]
USA_AIR
```

Out[21]:

| | Country | AIR | HAD | PMD | OZD | NOE | SOE | COE | VOE |
|---|---|---|---|---|---|---|---|---|---|
| **172** | United States of America | 77.0 | 97.2 | 74.6 | 36.7 | 15.2 | 34.7 | 54.9 | 34.8 |

In [22]:
```
#Pie Chart with factors in %  responsible for air quality in USA
air_data = [0.38*USA_AIR.HAD,0.47*USA_AIR.PMD,USA_AIR.OZD*0.05,USA_AIR.NOE*0.05,US
air_labels = ['Household Solid Fuels', 'PM2.5 Exposure', 'Ozone Exposure', 'NOx Ex
air_colors = sns.color_palette('Spectral')[0:5]
plt.pie(air_data, labels=air_labels,colors = air_colors, autopct = '%0.0f%%')
plt.show()
```




In [23]:

```
#Clustering
Global_West = HLT.loc[HLT['Region'] == 'Global West']
Binned_Global_West = Global_West
Binned_Global_West
```

Out[23]:

| | Country | Region | EPI | HLT | AIR | H2O | HMT | WMG |
|---|---|---|---|---|---|---|---|---|
| **7** | Australia | Global West | 60.1 | 86.4 | 91.1 | 87.1 | 76.4 | 69.0 |
| **8** | Austria | Global West | 66.5 | 81.7 | 75.0 | 94.7 | 90.7 | 77.4 |
| **15** | Belgium | Global West | 58.2 | 77.9 | 74.6 | 93.6 | 66.6 | 68.0 |
| **30** | Canada | Global West | 50.0 | 85.9 | 88.0 | 88.1 | 95.6 | 59.5 |
| **44** | Denmark | Global West | 77.9 | 85.5 | 80.5 | 97.5 | 100.0 | 68.3 |
| **57** | Finland | Global West | 76.5 | 93.4 | 93.5 | 100.0 | 100.0 | 69.6 |
| **58** | France | Global West | 62.5 | 83.9 | 82.0 | 96.3 | 83.1 | 63.8 |
| **62** | Germany | Global West | 62.4 | 82.0 | 75.2 | 99.1 | 89.8 | 69.0 |
| **73** | Iceland | Global West | 62.8 | 94.7 | 96.0 | 100.0 | 95.1 | 73.9 |
| **78** | Ireland | Global West | 57.4 | 88.3 | 89.1 | 97.4 | 81.8 | 67.9 |
| **80** | Italy | Global West | 57.7 | 76.9 | 69.4 | 98.3 | 80.6 | 60.6 |
| **95** | Luxembourg | Global West | 72.3 | 86.7 | 81.0 | 98.7 | 95.1 | 79.1 |
| **101** | Malta | Global West | 75.2 | 76.5 | 73.2 | 99.8 | 49.9 | 63.5 |
| **115** | Netherlands | Global West | 62.6 | 83.3 | 76.8 | 100.0 | 94.1 | 66.2 |
| **116** | New Zealand | Global West | 56.7 | 84.9 | 93.2 | 80.4 | 74.6 | 60.9 |
| **121** | Norway | Global West | 59.3 | 92.2 | 92.4 | 100.0 | 93.0 | 70.7 |
| **130** | Portugal | Global West | 50.4 | 76.6 | 78.1 | 83.5 | 64.6 | 62.5 |
| **151** | Spain | Global West | 56.6 | 78.1 | 74.0 | 96.9 | 70.5 | 61.4 |
| **155** | Sweden | Global West | 72.7 | 93.1 | 94.0 | 98.6 | 96.9 | 70.8 |
| **156** | Switzerland | Global West | 65.9 | 88.4 | 84.3 | 100.0 | 94.0 | 76.4 |
| **171** | United Kingdom | Global West | 77.7 | 83.9 | 78.6 | 100.0 | 93.6 | 62.6 |
| **172** | United States of America | Global West | 51.1 | 76.8 | 77.0 | 86.1 | 75.1 | 54.3 |

In [24]:

```
#Binning
Binned_Global_West['Binned'] = pd.cut(Binned_Global_West['HLT'], bins=3, labels=["
```

In [25]:

```
Binned_Global_West.sort_values(by=['Binned'], ascending=False)
```

Out[25]:

| | Country | Region | EPI | HLT | AIR | H2O | HMT | WMG | Binned |
|---|---|---|---|---|---|---|---|---|---|
| **155** | Sweden | Global West | 72.7 | 93.1 | 94.0 | 98.6 | 96.9 | 70.8 | High |
| **57** | Finland | Global West | 76.5 | 93.4 | 93.5 | 100.0 | 100.0 | 69.6 | High |
| **121** | Norway | Global West | 59.3 | 92.2 | 92.4 | 100.0 | 93.0 | 70.7 | High |
| **73** | Iceland | Global West | 62.8 | 94.7 | 96.0 | 100.0 | 95.1 | 73.9 | High |
| **7** | Australia | Global West | 60.1 | 86.4 | 91.1 | 87.1 | 76.4 | 69.0 | Mid |
| **115** | Netherlands | Global West | 62.6 | 83.3 | 76.8 | 100.0 | 94.1 | 66.2 | Mid |
| **171** | United Kingdom | Global West | 77.7 | 83.9 | 78.6 | 100.0 | 93.6 | 62.6 | Mid |
| **156** | Switzerland | Global West | 65.9 | 88.4 | 84.3 | 100.0 | 94.0 | 76.4 | Mid |
| **116** | New Zealand | Global West | 56.7 | 84.9 | 93.2 | 80.4 | 74.6 | 60.9 | Mid |
| **95** | Luxembourg | Global West | 72.3 | 86.7 | 81.0 | 98.7 | 95.1 | 79.1 | Mid |
| **78** | Ireland | Global West | 57.4 | 88.3 | 89.1 | 97.4 | 81.8 | 67.9 | Mid |
| **58** | France | Global West | 62.5 | 83.9 | 82.0 | 96.3 | 83.1 | 63.8 | Mid |
| **44** | Denmark | Global West | 77.9 | 85.5 | 80.5 | 97.5 | 100.0 | 68.3 | Mid |
| **30** | Canada | Global West | 50.0 | 85.9 | 88.0 | 88.1 | 95.6 | 59.5 | Mid |
| **80** | Italy | Global West | 57.7 | 76.9 | 69.4 | 98.3 | 80.6 | 60.6 | Low |
| **8** | Austria | Global West | 66.5 | 81.7 | 75.0 | 94.7 | 90.7 | 77.4 | Low |
| **101** | Malta | Global West | 75.2 | 76.5 | 73.2 | 99.8 | 49.9 | 63.5 | Low |
| **62** | Germany | Global West | 62.4 | 82.0 | 75.2 | 99.1 | 89.8 | 69.0 | Low |
| **130** | Portugal | Global West | 50.4 | 76.6 | 78.1 | 83.5 | 64.6 | 62.5 | Low |
| **151** | Spain | Global West | 56.6 | 78.1 | 74.0 | 96.9 | 70.5 | 61.4 | Low |
| **15** | Belgium | Global West | 58.2 | 77.9 | 74.6 | 93.6 | 66.6 | 68.0 | Low |
| **172** | United States of America | Global West | 51.1 | 76.8 | 77.0 | 86.1 | 75.1 | 54.3 | Low |

In [26]:

```
#HLT Table correlation
HLT.corr().sort_values('HLT', ascending=False)
```

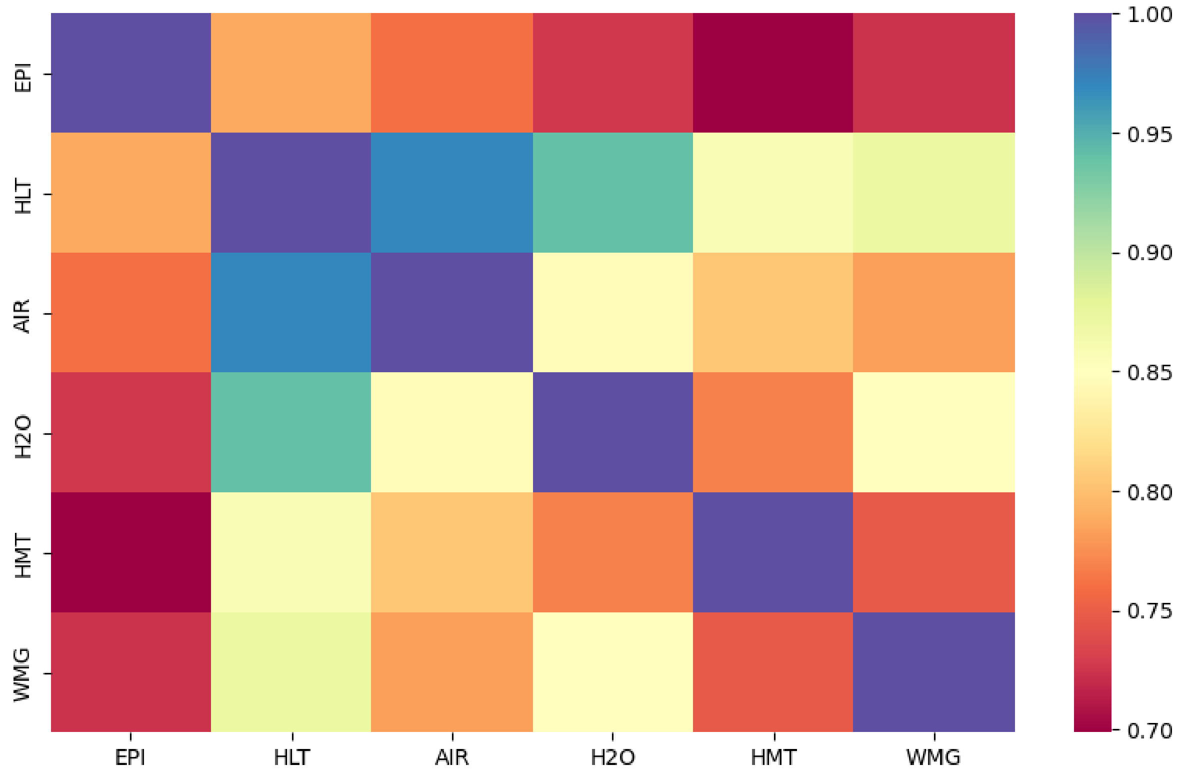
Out[26]:

| | EPI | HLT | AIR | H2O | HMT | WMG |
|---|---|---|---|---|---|---|
| **HLT** | 0.787318 | 1.000000 | 0.970419 | 0.940909 | 0.856427 | 0.870691 |
| **AIR** | 0.760892 | 0.970419 | 1.000000 | 0.844808 | 0.803768 | 0.782319 |
| **H2O** | 0.726705 | 0.940909 | 0.844808 | 1.000000 | 0.768442 | 0.848365 |
| **WMG** | 0.724086 | 0.870691 | 0.782319 | 0.848365 | 0.746793 | 1.000000 |
| **HMT** | 0.698676 | 0.856427 | 0.803768 | 0.768442 | 1.000000 | 0.746793 |
| **EPI** | 1.000000 | 0.787318 | 0.760892 | 0.726705 | 0.698676 | 0.724086 |

In [27]:

```
#Heatmap for Environmental Health
plt.figure(figsize = (10,6))
sns.heatmap(HLT.corr(), cmap="Spectral")
```

Out[27]: <AxesSubplot:>




In [28]:
```
#Ecosystem Vitality
ECO = EPI[['Country', 'Region', 'EPI', 'ECO',
           'BDH','ECS','FSH','ACD','AGR','WRS']]
ECO
```

Out[28]:

| | Country | Region | EPI | ECO | BDH | ECS | FSH | ACD | AGR | WRS |
|---|---|---|---|---|---|---|---|---|---|---|
| **0** | Afghanistan | Southern Asia | 43.6 | 36.9 | 30.7 | 61.8 | NaN | 35.5 | 44.2 | 0.0 |
| **1** | Albania | Eastern Europe | 47.1 | 45.5 | 63.9 | 24.2 | 17.3 | 90.2 | 28.9 | 1.9 |
| **2** | Algeria | Greater Middle East | 29.6 | 31.6 | 22.7 | 23.7 | 18.5 | 70.8 | 63.3 | 33.1 |
| **3** | Angola | Sub-Saharan Africa | 30.5 | 28.6 | 30.1 | 29.4 | 24.3 | 50.5 | 24.9 | 0.0 |
| **4** | Antigua and Barbuda | Latin America & Caribbean | 52.4 | 43.6 | 54.2 | 39.5 | 19.7 | 93.2 | 5.1 | 15.7 |
| **...** | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| **175** | Vanuatu | Asia-Pacific | 36.9 | 28.0 | 20.0 | 38.6 | 21.0 | 63.9 | 33.0 | 4.5 |
| **176** | Venezuela | Latin America & Caribbean | 46.4 | 52.0 | 71.5 | 33.6 | 27.7 | 74.0 | 43.6 | 6.4 |
| **177** | Viet Nam | Asia-Pacific | 20.1 | 22.1 | 27.9 | 8.5 | 24.2 | 19.3 | 39.6 | 0.3 |
| **178** | Zambia | Sub-Saharan Africa | 38.4 | 58.2 | 91.0 | 19.9 | NaN | 32.2 | 53.2 | 4.5 |
| **179** | Zimbabwe | Sub-Saharan Africa | 46.2 | 61.7 | 83.7 | 17.7 | NaN | 87.8 | 42.8 | 37.2 |

180 rows × 10 columns

In [29]:
```
ECO.corr().sort_values('ECO', ascending=False)
```

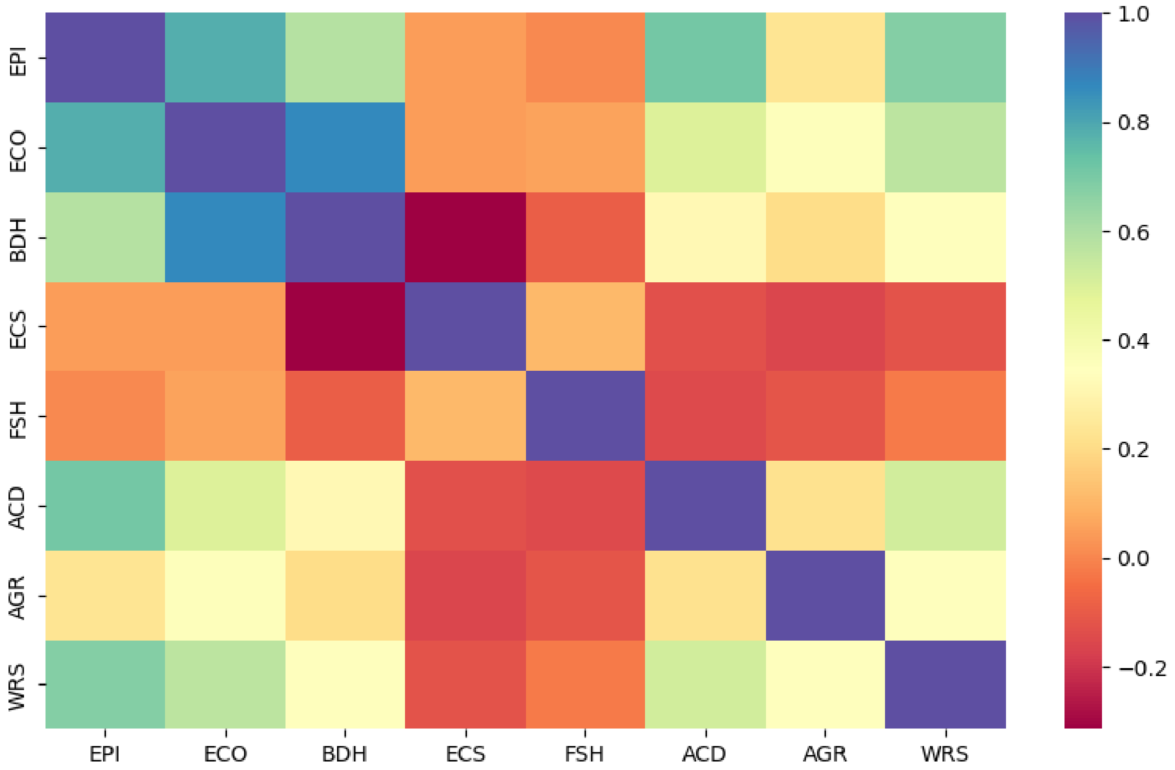
Out[29]:

| | EPI | ECO | BDH | ECS | FSH | ACD | AGR | WRS |
|---|---|---|---|---|---|---|---|---|
| **ECO** | 0.781626 | 1.000000 | 0.864343 | 0.047428 | 0.056680 | 0.495587 | 0.353924 | 0.563578 |
| **BDH** | 0.578987 | 0.864343 | 1.000000 | -0.315252 | -0.091273 | 0.316346 | 0.205035 | 0.350663 |
| **EPI** | 1.000000 | 0.781626 | 0.578987 | 0.049305 | 0.005269 | 0.708948 | 0.230961 | 0.678510 |
| **WRS** | 0.678510 | 0.563578 | 0.350663 | -0.120850 | -0.023635 | 0.517148 | 0.351885 | 1.000000 |
| **ACD** | 0.708948 | 0.495587 | 0.316346 | -0.135172 | -0.148010 | 1.000000 | 0.223374 | 0.517148 |
| **AGR** | 0.230961 | 0.353924 | 0.205035 | -0.159578 | -0.119157 | 0.223374 | 1.000000 | 0.351885 |
| **FSH** | 0.005269 | 0.056680 | -0.091273 | 0.106555 | 1.000000 | -0.148010 | -0.119157 | -0.023635 |
| **ECS** | 0.049305 | 0.047428 | -0.315252 | 1.000000 | 0.106555 | -0.135172 | -0.159578 | -0.120850 |

In [30]:

```
#Heatmap for Ecosystem Vitality
plt.figure(figsize = (10,6))
sns.heatmap(ECO.corr(), cmap="Spectral")
```

Out[30]: <AxesSubplot:>




In [31]:

```
x = ECO.BDH
y = ECO.ECO
stats.spearmanr(x,y)
```

Out[31]: SpearmanrResult(correlation=0.8829896851952493, pvalue=2.306222299508134e-60)

In [32]:

```
#Binning
Binned_ECO = ECO
ECO_Global_West = Binned_ECO.loc[Binned_ECO['Region'] == 'Global West']
ECO_Global_West['Binned'] = pd.cut(ECO_Global_West['ECO'], bins=3, labels=["Low",
ECO_Global_West.sort_values('Binned', ascending=False)
```

Out[32]:

| | Country | Region | EPI | ECO | BDH | ECS | FSH | ACD | AGR | WRS | Binned |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **95** | Luxembourg | Global West | 72.3 | 70.0 | 84.8 | 18.1 | 0.0 | 100.0 | 55.9 | 98.0 | High |
| **8** | Austria | Global West | 66.5 | 73.9 | 86.0 | 28.0 | 10.4 | 100.0 | 70.6 | 94.0 | High |
| **62** | Germany | Global West | 62.4 | 66.8 | 88.5 | 17.9 | 26.9 | 100.0 | 60.9 | 97.0 | High |
| **101** | Malta | Global West | 75.2 | 68.2 | 72.9 | 100.0 | 47.8 | 100.0 | 28.3 | 0.0 | High |
| **171** | United Kingdom | Global West | 77.7 | 62.3 | 81.5 | 23.6 | 17.0 | 100.0 | 45.0 | 99.0 | Mid |
| **156** | Switzerland | Global West | 65.9 | 60.2 | 62.5 | 30.7 | NaN | 100.0 | 41.1 | 97.0 | Mid |
| **155** | Sweden | Global West | 72.7 | 60.6 | 68.8 | 29.3 | 15.3 | 100.0 | 74.0 | 100.0 | Mid |
| **151** | Spain | Global West | 56.6 | 60.3 | 85.8 | 13.4 | 16.4 | 100.0 | 31.8 | 91.1 | Mid |
| **116** | New Zealand | Global West | 56.7 | 57.9 | 76.6 | 26.9 | 7.4 | 76.0 | 64.9 | 79.9 | Mid |
| **115** | Netherlands | Global West | 62.6 | 60.0 | 80.1 | 24.4 | 13.0 | 100.0 | 29.3 | 100.0 | Mid |
| **7** | Australia | Global West | 60.1 | 62.3 | 82.1 | 20.1 | 14.6 | 88.6 | 67.9 | 92.9 | Mid |
| **58** | France | Global West | 62.5 | 64.0 | 86.5 | 21.5 | 19.5 | 100.0 | 49.5 | 88.0 | Mid |
| **57** | Finland | Global West | 76.5 | 62.0 | 71.1 | 20.1 | 42.4 | 100.0 | 62.7 | 100.0 | Mid |
| **44** | Denmark | Global West | 77.9 | 61.3 | 76.9 | 16.4 | 10.9 | 100.0 | 75.7 | 100.0 | Mid |
| **15** | Belgium | Global West | 58.2 | 57.9 | 82.4 | 16.3 | 16.4 | 100.0 | 33.1 | 68.2 | Mid |
| **80** | Italy | Global West | 57.7 | 57.2 | 76.5 | 26.1 | 16.8 | 100.0 | 38.8 | 58.8 | Low |
| **78** | Ireland | Global West | 57.4 | 50.9 | 59.6 | 17.4 | 18.2 | 95.4 | 48.7 | 87.0 | Low |
| **73** | Iceland | Global West | 62.8 | 53.4 | 57.0 | 77.4 | 19.2 | 95.8 | 18.5 | 15.3 | Low |
| **121** | Norway | Global West | 59.3 | 57.6 | 71.2 | 30.8 | 39.7 | 100.0 | 25.5 | 64.3 | Low |
| **130** | Portugal | Global West | 50.4 | 49.6 | 70.5 | 8.6 | 14.7 | 100.0 | 23.5 | 59.2 | Low |
| **30** | Canada | Global West | 50.0 | 52.5 | 62.9 | 29.8 | 12.8 | 100.0 | 42.1 | 67.4 | Low |
| **172** | United States of America | Global West | 51.1 | 51.4 | 60.6 | 20.1 | 17.2 | 100.0 | 61.4 | 58.9 | Low |

## Frequent Pattern Mining using Apriori Algorithm

Luxembourg, Austria, Germany and Malta have the best Ecosystem Vitality score among countries lying in Global West

In [33]:
```
FP_AIR_df = epi2022[['country','region','AIR.new','HAD.new','PMD.new','OZD.new','N
FP_AIR_df.columns = ['Country','Region','AIR','HAD','PMD','OZD','NOE','SOE','COE',
```

In [34]:
```
FP_AIR_df['AIR_BIN'] = pd.cut(FP_AIR_df['AIR'], bins=3, labels=["Poor AIR", "Averag
FP_AIR_df['HAD_BIN'] = pd.cut(FP_AIR_df['HAD'], bins=3, labels=["Poor HAD", "Averag
FP_AIR_df['PMD_BIN'] = pd.cut(FP_AIR_df['PMD'], bins=3, labels=["Poor PMD", "Averag
FP_AIR_df['OZD_BIN'] = pd.cut(FP_AIR_df['OZD'], bins=3, labels=["Poor OZD", "Averag
FP_AIR_df['NOE_BIN'] = pd.cut(FP_AIR_df['NOE'], bins=3, labels=["Poor NOE", "Averag
FP_AIR_df['SOE_BIN'] = pd.cut(FP_AIR_df['SOE'], bins=3, labels=["Poor SOE", "Averag
FP_AIR_df['COE_BIN'] = pd.cut(FP_AIR_df['COE'], bins=3, labels=["Poor COE", "Averag
FP_AIR_df['VOE_BIN'] = pd.cut(FP_AIR_df['VOE'], bins=3, labels=["Poor VOE", "Averag
FP_AIR_df
```

Out[34]:

| | Country | Region | AIR | HAD | PMD | OZD | NOE | SOE | COE | VOE | AIR_BIN | HAD_BIN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **0** | Afghanistan | Southern Asia | 15.5 | 7.4 | 16.0 | 18.4 | 37.8 | 61.2 | 42.7 | 37.5 | Poor AIR | Poor HAD |
| **1** | Albania | Eastern Europe | 37.5 | 34.5 | 36.7 | 63.7 | 29.5 | 43.3 | 61.5 | 46.9 | Average AIR | Average HAD |
| **2** | Algeria | Greater Middle East | 39.4 | 78.4 | 12.1 | 35.6 | 8.2 | 27.6 | 39.9 | 30.7 | Average AIR | Great HAD |
| **3** | Angola | Sub-Saharan Africa | 23.1 | 17.9 | 24.0 | 36.8 | 32.4 | 60.2 | 30.3 | 8.3 | Poor AIR | Poor HAD |
| **4** | Antigua and Barbuda | Latin America & Caribbean | 56.5 | 69.3 | 37.1 | 100.0 | 77.2 | 62.2 | 91.6 | 91.4 | Average AIR | Great HAD |
| **...** | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| **175** | Vanuatu | Asia-Pacific | 30.7 | 6.1 | 34.5 | 62.7 | 100.0 | 82.8 | 100.0 | 71.2 | Poor AIR | Poor HAD |
| **176** | Venezuela | Latin America & Caribbean | 46.7 | 74.4 | 25.1 | 59.2 | 30.5 | 60.6 | 58.2 | 10.5 | Average AIR | Great HAD |
| **177** | Viet Nam | Asia-Pacific | 26.5 | 24.9 | 28.4 | 41.3 | 14.9 | 33.2 | 8.4 | 17.6 | Poor AIR | Poor HAD |
| **178** | Zambia | Sub-Saharan Africa | 23.6 | 12.6 | 28.6 | 36.4 | 37.6 | 43.9 | 46.6 | 12.8 | Poor AIR | Poor HAD |
| **179** | Zimbabwe | Sub-Saharan Africa | 23.9 | 10.4 | 30.1 | 43.5 | 34.8 | 55.0 | 45.5 | 17.7 | Poor AIR | Poor HAD |

180 rows × 18 columns

In [35]:
```
FP_AIR_df.drop(['AIR','HAD','PMD','OZD','NOE','SOE','COE','VOE'], axis=1)
```

Out[35]:

| | Country | Region | AIR_BIN | HAD_BIN | PMD_BIN | OZD_BIN | NOE_BIN | SOE_BIN | COE_BI |
|---|---|---|---|---|---|---|---|---|---|
| **0** | Afghanistan | Southern Asia | Poor AIR | Poor HAD | Poor PMD | Poor OZD | Average NOE | Average SOE | Averag CC |
| **1** | Albania | Eastern Europe | Average AIR | Average HAD | Average PMD | Average OZD | Poor NOE | Average SOE | Averag CC |
| **2** | Algeria | Greater Middle East | Average AIR | Great HAD | Poor PMD | Average OZD | Poor NOE | Poor SOE | Averag CC |
| **3** | Angola | Sub-Saharan Africa | Poor AIR | Poor HAD | Poor PMD | Average OZD | Poor NOE | Average SOE | Poc CC |
| **4** | Antigua and Barbuda | Latin America & Caribbean | Average AIR | Great HAD | Average PMD | Great OZD | Great NOE | Average SOE | Grea CC |
| **...** | ... | ... | ... | ... | ... | ... | ... | ... | |
| **175** | Vanuatu | Asia-Pacific | Poor AIR | Poor HAD | Average PMD | Average OZD | Great NOE | Great SOE | Grea CC |
| **176** | Venezuela | Latin America & Caribbean | Average AIR | Great HAD | Poor PMD | Average OZD | Poor NOE | Average SOE | Averag CC |
| **177** | Viet Nam | Asia-Pacific | Poor AIR | Poor HAD | Poor PMD | Average OZD | Poor NOE | Poor SOE | Poc CC |
| **178** | Zambia | Sub-Saharan Africa | Poor AIR | Poor HAD | Poor PMD | Average OZD | Average NOE | Average SOE | Averag CC |
| **179** | Zimbabwe | Sub-Saharan Africa | Poor AIR | Poor HAD | Poor PMD | Average OZD | Average NOE | Average SOE | Averag CC |

180 rows × 10 columns

APRIORI ALGORITHM (AIR DATASET)

In [36]:
```
def load_df():
    return FP_AIR_df.values.tolist()
def gen_cand1(itemset):
    CANDIDATE1 = []
    for i in itemset:
        for j in i:
            if not [j] in CANDIDATE1:
                CANDIDATE1.append([j])
    return list(map(frozenset, CANDIDATE1))
itemset = load_df()
CANDIDATE1 = gen_cand1(itemset)

def database_scan(Db, Ck, min_sup):
    sup_count = {}
    sup_data = {}
```

```python
    r_list = []
    Db_length = len(Db)
    for t in Db:
        for i in Ck:
            if i.issubset(t):
                if not i in sup_count: sup_count[i]=1
                else: sup_count[i] += 1

    total_items = int(Db_length)
    for key in sup_count:
        support = sup_count[key]/total_items
        if support >= min_sup:
            r_list.insert(0,key)
        sup_data[key] = support
    return r_list, sup_data

def generate_apriori(L_k, k):
    Ck = []
    for l in range(len(L_k)):
        for i in range(l+1, len(L_k)):
            l1 = list(L_k[l])[:k-2]
            l2 = list(L_k[i])[:k-2]
            l1.sort()
            l2.sort()
            if l1==l2:
                Ck.append(L_k[l] | L_k[i])
    return Ck

def apriori(itemset, min_sup = 0.12):
    CANDIDATE1 = gen_cand1(itemset)
    D = list(map(set, itemset))
    L1, sup_data = database_scan(D, CANDIDATE1, min_sup)
    L = [L1]
    k = 2
    while (len(L[k-2]) > 0):
        Ck = generate_apriori(L[k-2], k)
        L_k, sup = database_scan(D, Ck, min_sup)
        sup_data.update(sup)
        L.append(L_k)
        k += 1
    return L, sup_data
L,sdata = apriori(itemset)
new_list = []
for index in range(len(L)):
    print("\nL{} ".format(index))
    print("Number of patterns={} \n".format(len(L[index])))
    apriori_freq_pattern = [list(i) for i in L[index]]
    print(apriori_freq_pattern)
```

L0
Number of patterns=29

[['Asia-Pacific'], [0.0], ['Great AIR'], ['Global West'], ['Great SOE'], ['Great V
OE'], ['Great COE'], ['Great NOE'], ['Great OZD'], [100.0], ['Latin America & Cari
bbean'], ['Poor COE'], ['Sub-Saharan Africa'], ['Poor VOE'], ['Poor SOE'], ['Great
HAD'], ['Poor NOE'], ['Average OZD'], ['Average PMD'], ['Average HAD'], ['Average
AIR'], ['Average VOE'], ['Average COE'], ['Average SOE'], ['Average NOE'], ['Poor
OZD'], ['Poor PMD'], ['Poor HAD'], ['Poor AIR']]

L1
Number of patterns=114

[['Average PMD', 'Poor AIR'], ['Average PMD', 'Poor HAD'], ['Sub-Saharan Africa',
'Average COE'], ['Great SOE', 'Poor AIR'], ['Great SOE', 'Poor HAD'], ['Average NO
E', 'Sub-Saharan Africa'], ['Average NOE', 'Average OZD'], ['Poor VOE', 'Average N
OE'], ['Great SOE', 'Poor PMD'], [0.0, 'Poor AIR'], [0.0, 'Poor NOE'], [0.0, 'Poor
VOE'], [0.0, 'Poor COE'], ['Poor SOE', 'Poor AIR'], ['Poor VOE', 'Poor OZD'], ['Po
or COE', 'Poor OZD'], ['Poor SOE', 'Poor COE'], ['Great SOE', 'Great COE'], ['Aver
age VOE', 'Great HAD'], ['Great HAD', 'Global West'], ['Poor NOE', 'Great AIR'],
['Great HAD', 'Great AIR'], ['Great AIR', 'Global West'], ['Average HAD', 'Poor PM
D'], ['Poor OZD', 'Poor NOE'], ['Average PMD', 'Poor VOE'], ['Average PMD', 'Great
SOE'], ['Great SOE', 'Average OZD'], ['Great SOE', 'Poor VOE'], ['Great HAD', 'Ave
rage SOE'], ['Average AIR', 'Latin America & Caribbean'], ['Great HAD', 100.0], [1
00.0, 'Great COE'], ['Great NOE', 'Great COE'], ['Great VOE', 100.0], ['Great VO
E', 'Great COE'], ['Average OZD', 'Poor AIR'], ['Poor HAD', 'Average OZD'], ['Poor
NOE', 'Poor AIR'], ['Poor HAD', 'Poor NOE'], ['Poor VOE', 'Poor AIR'], ['Poor VO
E', 'Poor HAD'], ['Poor VOE', 'Average SOE'], ['Sub-Saharan Africa', 'Poor AIR'],
['Poor HAD', 'Sub-Saharan Africa'], ['Sub-Saharan Africa', 'Poor PMD'], ['Sub-Saha
ran Africa', 'Average OZD'], ['Poor VOE', 'Sub-Saharan Africa'], ['Poor COE', 'Poo
r AIR'], ['Poor COE', 'Poor HAD'], ['Poor COE', 'Poor PMD'], ['Poor COE', 'Average
OZD'], ['Poor COE', 'Poor NOE'], ['Poor VOE', 'Poor COE'], ['Average AIR', 'Poor P
MD'], ['Poor PMD', 'Average OZD'], ['Poor NOE', 'Poor PMD'], ['Great HAD', 'Averag
e COE'], ['Average AIR', 'Great HAD'], ['Great HAD', 'Average OZD'], ['Great HAD',
'Poor NOE'], ['Poor SOE', 'Poor PMD'], ['Poor SOE', 'Average OZD'], ['Poor SOE',
'Poor NOE'], ['Poor VOE', 'Poor PMD'], ['Poor VOE', 'Average COE'], ['Average AI
R', 'Poor VOE'], ['Poor VOE', 'Average OZD'], ['Poor VOE', 'Poor NOE'], ['Poor VO
E', 'Poor SOE'], ['Average AIR', 'Average SOE'], ['Average AIR', 'Average COE'],
['Average AIR', 'Average VOE'], ['Average COE', 'Average HAD'], ['Average VOE', 'A
verage HAD'], ['Average AIR', 'Average HAD'], ['Average PMD', 'Average SOE'], ['Av
erage PMD', 'Average COE'], ['Average PMD', 'Average AIR'], ['Average PMD', 'Avera
ge HAD'], ['Average SOE', 'Average OZD'], ['Average COE', 'Average OZD'], ['Averag
e VOE', 'Average OZD'], ['Average AIR', 'Average OZD'], ['Average HAD', 'Average O
ZD'], ['Average PMD', 'Average OZD'], ['Poor NOE', 'Average SOE'], ['Poor NOE', 'A
verage COE'], ['Average VOE', 'Poor NOE'], ['Average AIR', 'Poor NOE'], ['Poor NO
E', 'Average HAD'], ['Average PMD', 'Poor NOE'], ['Poor NOE', 'Average OZD'], ['Po
or HAD', 'Poor AIR'], ['Poor PMD', 'Poor AIR'], ['Poor HAD', 'Poor PMD'], ['Poor O
ZD', 'Poor AIR'], ['Poor OZD', 'Poor HAD'], ['Poor OZD', 'Poor PMD'], ['Average NO
E', 'Poor AIR'], ['Average NOE', 'Poor HAD'], ['Average NOE', 'Poor PMD'], ['Avera
ge SOE', 'Poor AIR'], ['Poor HAD', 'Average SOE'], ['Average SOE', 'Poor PMD'],
['Average NOE', 'Average SOE'], ['Average COE', 'Poor AIR'], ['Poor HAD', 'Average
COE'], ['Average COE', 'Poor PMD'], ['Average NOE', 'Average COE'], ['Average SO
E', 'Average COE'], ['Average VOE', 'Poor PMD'], ['Average VOE', 'Average SOE'],
['Average VOE', 'Average COE']]

L2
Number of patterns=121

[['Average PMD', 'Poor VOE', 'Poor HAD'], ['Average PMD', 'Poor VOE', 'Poor AIR'],
['Average PMD', 'Poor HAD', 'Poor AIR'], ['Poor VOE', 'Poor HAD', 'Average COE'],
['Poor VOE', 'Average COE', 'Poor AIR'], ['Poor HAD', 'Average COE', 'Average OZ
D'], ['Poor VOE', 'Average NOE', 'Average COE'], ['Great SOE', 'Poor HAD', 'Poor A
IR'], ['Poor VOE', 'Average NOE', 'Sub-Saharan Africa'], ['Poor VOE', 'Average NO
E', 'Poor HAD'], ['Poor VOE', 'Average NOE', 'Poor AIR'], ['Average NOE', 'Sub-Sah

aran Africa', 'Poor HAD'], ['Average NOE', 'Sub-Saharan Africa', 'Poor AIR'], ['Po
or VOE', 'Average NOE', 'Poor PMD'], ['Poor VOE', 'Poor OZD', 'Poor HAD'], ['Poor
VOE', 'Poor COE', 'Poor SOE'], ['Poor SOE', 'Poor COE', 'Poor NOE'], ['Poor VOE',
'Poor OZD', 'Poor PMD'], ['Poor VOE', 'Poor OZD', 'Poor COE'], ['Poor VOE', 'Poor
OZD', 'Poor AIR'], ['Poor SOE', 'Poor NOE', 'Poor AIR'], ['Poor SOE', 'Poor PMD',
'Poor AIR'], ['Average COE', 'Average OZD', 'Poor AIR'], ['Great HAD', 'Average SO
E', 'Average OZD'], ['Average VOE', 'Great HAD', 'Poor NOE'], ['Average VOE', 'Gre
at HAD', 'Average OZD'], ['Poor NOE', 'Great HAD', 'Average SOE'], ['Great HAD',
'Average SOE', 'Average COE'], ['Great HAD', 'Great AIR', 'Global West'], ['Averag
e VOE', 'Poor NOE', 'Poor PMD'], ['Poor NOE', 'Average COE', 'Poor AIR'], ['Poor O
ZD', 'Poor NOE', 'Poor AIR'], ['Average PMD', 'Poor VOE', 'Poor NOE'], ['Average P
MD', 'Poor VOE', 'Average OZD'], ['Poor PMD', 'Average OZD', 'Poor AIR'], ['Poor V
OE', 'Poor COE', 'Poor NOE'], ['Poor VOE', 'Poor COE', 'Poor PMD'], ['Poor COE',
'Poor NOE', 'Average OZD'], ['Poor COE', 'Poor NOE', 'Poor PMD'], ['Poor COE', 'Po
or NOE', 'Poor AIR'], ['Poor COE', 'Poor PMD', 'Poor AIR'], ['Poor COE', 'Poor HA
D', 'Poor AIR'], ['Poor VOE', 'Sub-Saharan Africa', 'Average OZD'], ['Poor VOE',
'Sub-Saharan Africa', 'Poor PMD'], ['Poor HAD', 'Sub-Saharan Africa', 'Poor PMD'],
['Poor HAD', 'Sub-Saharan Africa', 'Poor AIR'], ['Sub-Saharan Africa', 'Average OZ
D', 'Poor AIR'], ['Sub-Saharan Africa', 'Poor PMD', 'Poor AIR'], ['Poor VOE', 'Ave
rage SOE', 'Poor PMD'], ['Poor VOE', 'Poor HAD', 'Poor NOE'], ['Poor VOE', 'Poor H
AD', 'Average OZD'], ['Poor VOE', 'Poor HAD', 'Poor PMD'], ['Poor VOE', 'Poor HA
D', 'Poor COE'], ['Poor VOE', 'Poor HAD', 'Sub-Saharan Africa'], ['Poor VOE', 'Poo
r HAD', 'Average SOE'], ['Poor VOE', 'Poor NOE', 'Poor AIR'], ['Poor VOE', 'Averag
e OZD', 'Poor AIR'], ['Poor VOE', 'Poor PMD', 'Poor AIR'], ['Poor VOE', 'Poor CO
E', 'Poor AIR'], ['Poor VOE', 'Sub-Saharan Africa', 'Poor AIR'], ['Poor VOE', 'Ave
rage SOE', 'Poor AIR'], ['Poor VOE', 'Poor HAD', 'Poor AIR'], ['Poor HAD', 'Poor N
OE', 'Poor AIR'], ['Poor NOE', 'Average OZD', 'Poor AIR'], ['Poor NOE', 'Poor PM
D', 'Poor AIR'], ['Poor HAD', 'Average OZD', 'Poor AIR'], ['Poor HAD', 'Sub-Sahara
n Africa', 'Average OZD'], ['Poor PMD', 'Average COE', 'Average OZD'], ['Poor VO
E', 'Poor SOE', 'Poor NOE'], ['Poor VOE', 'Poor NOE', 'Average OZD'], ['Poor VOE',
'Average COE', 'Average OZD'], ['Poor VOE', 'Poor NOE', 'Poor PMD'], ['Poor VOE',
'Average OZD', 'Poor PMD'], ['Poor SOE', 'Poor NOE', 'Average OZD'], ['Poor SOE',
'Poor NOE', 'Poor PMD'], ['Great HAD', 'Poor NOE', 'Average OZD'], ['Great HAD',
'Poor NOE', 'Average COE'], ['Great HAD', 'Average COE', 'Average OZD'], ['Average
OZD', 'Poor NOE', 'Poor PMD'], ['Poor NOE', 'Average COE', 'Poor PMD'], ['Poor NO
E', 'Average HAD', 'Average OZD'], ['Average VOE', 'Poor NOE', 'Average COE'], ['A
verage VOE', 'Poor NOE', 'Average SOE'], ['Poor NOE', 'Average COE', 'Average OZ
D'], ['Average HAD', 'Poor NOE', 'Average COE'], ['Poor NOE', 'Average OZD', 'Aver
age SOE'], ['Poor NOE', 'Average COE', 'Average SOE'], ['Average PMD', 'Poor NOE',
'Average OZD'], ['Average AIR', 'Poor NOE', 'Average OZD'], ['Average VOE', 'Avera
ge COE', 'Average OZD'], ['Average VOE', 'Average SOE', 'Average OZD'], ['Average
VOE', 'Poor NOE', 'Average OZD'], ['Average SOE', 'Average COE', 'Average OZD'],
['Average PMD', 'Poor NOE', 'Average AIR'], ['Average PMD', 'Average AIR', 'Averag
e OZD'], ['Average PMD', 'Average HAD', 'Average AIR'], ['Average PMD', 'Poor NO
E', 'Average COE'], ['Average PMD', 'Average COE', 'Average OZD'], ['Average PMD',
'Average SOE', 'Poor NOE'], ['Average PMD', 'Average SOE', 'Average OZD'], ['Avera
ge AIR', 'Poor NOE', 'Average HAD'], ['Average AIR', 'Poor NOE', 'Average COE'],
['Average AIR', 'Average COE', 'Average OZD'], ['Average AIR', 'Average SOE', 'Poo
r NOE'], ['Average VOE', 'Average SOE', 'Average COE'], ['Average VOE', 'Average C
OE', 'Poor PMD'], ['Average COE', 'Poor PMD', 'Poor AIR'], ['Average SOE', 'Averag
e COE', 'Poor PMD'], ['Average SOE', 'Poor PMD', 'Poor AIR'], ['Average COE', 'Ave
rage NOE', 'Poor HAD'], ['Average NOE', 'Poor HAD', 'Poor PMD'], ['Average NOE',
'Average COE', 'Poor AIR'], ['Average NOE', 'Poor PMD', 'Poor AIR'], ['Average NO
E', 'Poor HAD', 'Poor AIR'], ['Poor OZD', 'Poor HAD', 'Poor PMD'], ['Poor OZD', 'P
oor PMD', 'Poor AIR'], ['Poor OZD', 'Poor HAD', 'Poor AIR'], ['Poor HAD', 'Average
SOE', 'Poor PMD'], ['Poor HAD', 'Average COE', 'Poor AIR'], ['Poor HAD', 'Average
SOE', 'Poor AIR'], ['Poor HAD', 'Poor PMD', 'Poor AIR']]

L3
Number of patterns=31

[['Poor VOE', 'Average COE', 'Poor HAD', 'Poor AIR'], ['Average NOE', 'Poor HAD',
'Sub-Saharan Africa', 'Poor AIR'], ['Poor VOE', 'Average NOE', 'Poor PMD', 'Poor A
IR'], ['Poor VOE', 'Average NOE', 'Poor HAD', 'Poor AIR'], ['Poor VOE', 'Average N

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OE', 'Sub-Saharan Africa', 'Poor AIR'], ['Poor VOE', 'Average NOE', 'Poor HAD', 'S
ub-Saharan Africa'], ['Poor VOE', 'Poor HAD', 'Poor OZD', 'Poor AIR'], ['Poor SO
E', 'Poor NOE', 'Poor PMD', 'Poor AIR'], ['Poor VOE', 'Poor COE', 'Poor SOE', 'Poo
r NOE'], ['Great HAD', 'Average COE', 'Poor NOE', 'Average SOE'], ['Poor VOE', 'Po
or HAD', 'Average SOE', 'Poor AIR'], ['Poor VOE', 'Poor HAD', 'Sub-Saharan Afric
a', 'Poor AIR'], ['Poor VOE', 'Poor COE', 'Poor HAD', 'Poor AIR'], ['Poor VOE', 'P
oor HAD', 'Poor PMD', 'Poor AIR'], ['Poor VOE', 'Poor HAD', 'Sub-Saharan Africa',
'Poor PMD'], ['Poor VOE', 'Poor HAD', 'Average OZD', 'Poor AIR'], ['Poor VOE', 'Po
or HAD', 'Poor NOE', 'Poor AIR'], ['Poor HAD', 'Sub-Saharan Africa', 'Poor PMD',
'Poor AIR'], ['Poor VOE', 'Sub-Saharan Africa', 'Poor PMD', 'Poor AIR'], ['Poor VO
E', 'Poor COE', 'Poor PMD', 'Poor AIR'], ['Poor VOE', 'Poor COE', 'Poor NOE', 'Poo
r AIR'], ['Poor VOE', 'Poor COE', 'Poor NOE', 'Poor PMD'], ['Great HAD', 'Average
COE', 'Poor NOE', 'Average OZD'], ['Average VOE', 'Average COE', 'Average SOE', 'A
verage OZD'], ['Average COE', 'Poor NOE', 'Average OZD', 'Average SOE'], ['Average
VOE', 'Poor NOE', 'Average OZD', 'Average SOE'], ['Average VOE', 'Average COE', 'P
oor NOE', 'Average OZD'], ['Average VOE', 'Average COE', 'Poor NOE', 'Average SO
E'], ['Poor HAD', 'Average SOE', 'Poor PMD', 'Poor AIR'], ['Poor HAD', 'Poor OZD',
'Poor PMD', 'Poor AIR'], ['Average NOE', 'Poor HAD', 'Poor PMD', 'Poor AIR']]

L4
Number of patterns=3

[['Average NOE', 'Sub-Saharan Africa', 'Poor AIR', 'Poor VOE', 'Poor HAD'], ['Sub-
Saharan Africa', 'Poor AIR', 'Poor VOE', 'Poor HAD', 'Poor PMD'], ['Average VOE',
'Average COE', 'Average SOE', 'Average OZD', 'Poor NOE']]

L5
Number of patterns=0

[]
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['Poor VOE', 'Poor HAD', 'Poor AIR', 'Average NOE', 'Sub-Saharan Africa']
['Poor VOE', 'Poor HAD', 'Poor AIR', 'Sub-Saharan Africa', 'Poor PMD']

It can be inferred that there is a good chance that if a country has Poor VOE, Poor HAD, Poor AIR, Average NOE it lies in Sub-Saharan Africa
Similarly, it can also be inferred that there is a good chance that if a country has Poor VOE, Poor HAD, Poor AIR, Poor PMD it lies in Sub-Saharan Africa

# Observations

1) EPI Score has three major components a) Climate Change Mitigation Score b) Environmental Health Score c) Ecosystem Vitality Score
2) Envirnoment Health scores of Global west countries are very high whereas scores of Sub Saharan African countries are very poor.
3) Ecosystem Vitality scores of Global west and Eastern Europe countries are quite high.
4) All the countries which have Very Good EPI score lie in Global West.
5) It is evident that CO2 Growth Rate (CDA) is the biggest factor in Climate Change. In order to mitigate climate change CO2 has to be reduced. CO2 growth rate can be defined as the average annual rate of increase or decrease in raw carbon dioxide emissions over the years
6) Iceland, Norway, Sweden, Finland have the best EPI scores among countries lying in Global West regions.
7) Air Quality scores of Southern Asian countries are very bad while that of Global West are very impressive
8) Water Quality scores of Sub Saharan Africa region is worst while Global West and Eastern

Europe have good scores.
9) Luxembourg, Austria, Germany and Malta have the best Ecosystem Vitality score among countries lying in Global West
10) It can be inferred that there is a good chance that if a country has Poor VOE, Poor HAD, Poor AIR, Average NOE it lies in Sub-Saharan Africa
11) Similarly, it can also be inferred that there is a good chance that if a country has Poor VOE, Poor HAD, Poor AIR, Poor PMD it lies in Sub-Saharan Africa