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# 5CS037

# Concepts and Technologies of AI

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# Introduction:

The World Health Report is an annual publication that ranks countries based on their levels of happiness and well-being. These rankings are determined by various factors, such as income, social support, life expectancy, freedom to life choices, generosity and perceptions of corruption.

In this analysis, we will explore the World Happiness Report dataset and perform a series of tasks to better understand happiness scores across South Asia and the Middle East. The task is divided into three sections, Data Exploration and Basic Analysis, Advanced Data Exploration and Comparative Analysis.

All the code related into making of this report is at this github repository: https://github.com/PS-Wizard/School/tree/main/ai

# Problem - 1: World Health Report

## 1.1 Load the dataset and display the first 10 rows.

| | score | Log GDP per capita | Social support | Healthy life expectancy | Freedom to make life choices | Generosity | Perceptions of corruption | Dystopia + residual |
|---|---|---|---|---|---|---|---|---|
| count | 143.000000 | 140.000000 | 140.000000 | 140.000000 | 140.000000 | 140.000000 | 140.000000 | 140.000000 |
| mean | 5.527580 | 1.378807 | 1.134329 | 0.520886 | 0.620621 | 0.146271 | 0.154121 | 1.575914 |
| std | 1.170717 | 0.425098 | 0.333317 | 0.164923 | 0.162492 | 0.073441 | 0.126238 | 0.537459 |
| min | 1.721000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | -0.073000 |
| 25% | 4.726000 | 1.077750 | 0.921750 | 0.398000 | 0.527500 | 0.091000 | 0.068750 | 1.308250 |
| 50% | 5.785000 | 1.431500 | 1.237500 | 0.549500 | 0.641000 | 0.136500 | 0.120500 | 1.644500 |
| 75% | 6.416000 | 1.741500 | 1.383250 | 0.648500 | 0.736000 | 0.192500 | 0.193750 | 1.881750 |
| max | 7.741000 | 2.141000 | 1.617000 | 0.857000 | 0.863000 | 0.401000 | 0.575000 | 2.998000 |

Fig 1.1: Description of the Entire World Health Report

| | Country name | score | Log GDP per capita | Social support | Healthy life expectancy | Freedom to make life choices | Generosity | Perceptions of corruption | Dystopia + residual |
|---|---|---|---|---|---|---|---|---|---|
| 0 | Finland | 7.741 | 1.844 | 1.572 | 0.695 | 0.859 | 0.142 | 0.546 | 2.082 |
| 1 | Denmark | 7.583 | 1.908 | 1.520 | 0.699 | 0.823 | 0.204 | 0.548 | 1.881 |
| 2 | Iceland | 7.525 | 1.881 | 1.617 | 0.718 | 0.819 | 0.258 | 0.182 | 2.050 |
| 3 | Sweden | 7.344 | 1.878 | 1.501 | 0.724 | 0.838 | 0.221 | 0.524 | 1.658 |
| 4 | Israel | 7.341 | 1.803 | 1.513 | 0.740 | 0.641 | 0.153 | 0.193 | 2.298 |
| 5 | Netherlands | 7.319 | 1.901 | 1.462 | 0.706 | 0.725 | 0.247 | 0.372 | 1.906 |
| 6 | Norway | 7.302 | 1.952 | 1.517 | 0.704 | 0.835 | 0.224 | 0.484 | 1.586 |
| 7 | Luxembourg | 7.122 | 2.141 | 1.355 | 0.708 | 0.801 | 0.146 | 0.432 | 1.540 |
| 8 | Switzerland | 7.060 | 1.970 | 1.425 | 0.747 | 0.759 | 0.173 | 0.498 | 1.488 |
| 9 | Australia | 7.057 | 1.854 | 1.461 | 0.692 | 0.756 | 0.225 | 0.323 | 1.745 |

Fig 1.2: First 10 rows from the World Health Report

From the image, we can interpret that all of the columns are numerical with an exception for `Country name`.

## 1.2 Identify the number of rows and columns in the dataset.

```
(143, 9)
```

Fig 1.3: Number of rows and columns in the dataset

The results show that there are 143 country's data in the World Health Report.

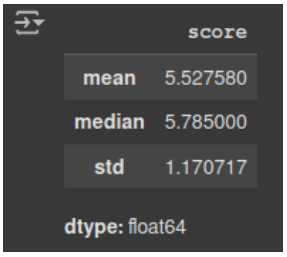
## 1.3 List all the columns and their data types.

| | 0 |
|---|---|
| Country name | object |
| score | float64 |
| Log GDP per capita | float64 |
| Social support | float64 |
| Healthy life expectancy | float64 |
| Freedom to make life choices | float64 |
| Generosity | float64 |
| Perceptions of corruption | float64 |
| Dystopia + residual | float64 |

dtype: object

Fig 1.4: The datatypes of all the columns in the dataset

## 2.1 Calculate the mean, median, and standard deviation for the Score column



| | score |
|---|---|
| mean | 5.527580 |
| median | 5.785000 |
| std | 1.170717 |

dtype: float64

Fig 1.5: Mean, Median and standard deviation of the score column

The results show that the median is greater than mean, which indicates that the data is skewed in the lower end as countries with lower happiness scores are pulling the average mean down. The standard deviation of ~ 1.2 indicates some spread in the data.

## 2.2 Identify the country with the highest and lowest happiness scores

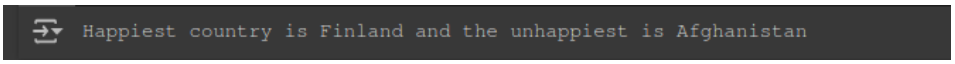
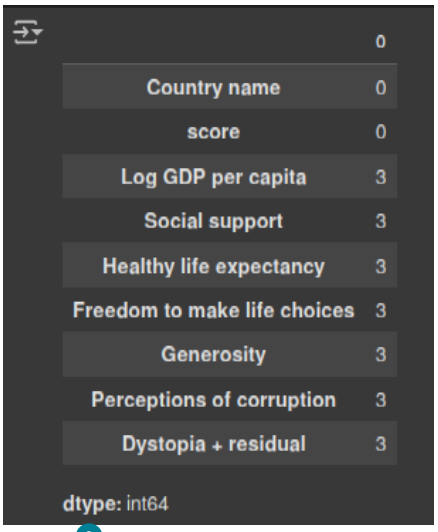



Fig 1.6: Identification of the happiest and unhappiest country in the dataset

---

## 3.1 Check if there are any missing values in the dataset. If so, display the total count for each column

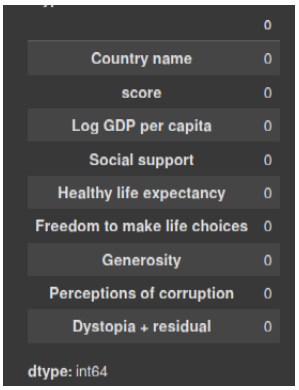


| | 0 |
|---|---|
| Country name | 0 |
| score | 0 |
| Log GDP per capita | 3 |
| Social support | 3 |
| Healthy life expectancy | 3 |
| Freedom to make life choices | 3 |
| Generosity | 3 |
| Perceptions of corruption | 3 |
| Dystopia + residual | 3 |

dtype: int64

Fig 1.7: Image displaying the number of missing values in each column of the dataset

The results show a few missing values all in the numerical columns. Dropping these rows, would result in losing entire countries from the dataset, which was already containing only 143 countries. So the data were filled with the median. I chose median because we previously saw skewness in the data.



| | 0 |
|---|---|
| Country name | 0 |
| score | 0 |
| Log GDP per capita | 0 |
| Social support | 0 |
| Healthy life expectancy | 0 |
| Freedom to make life choices | 0 |
| Generosity | 0 |
| Perceptions of corruption | 0 |
| Dystopia + residual | 0 |

dtype: int64

Fig 1.8: Image after treating the missing values.

---

## 4.1 Filter the dataset to show only the countries with a Score greater than 7.5

| | Country name | score | Log GDP per capita | Social support | Healthy life expectancy | Freedom to make life choices | Generosity | Perceptions of corruption | Dystopia + residual |
|---|---|---|---|---|---|---|---|---|---|
| 0 | Finland | 7.741 | 1.844 | 1.572 | 0.695 | 0.859 | 0.142 | 0.546 | 2.082 |
| 1 | Denmark | 7.583 | 1.908 | 1.520 | 0.699 | 0.823 | 0.204 | 0.548 | 1.881 |
| 2 | Iceland | 7.525 | 1.881 | 1.617 | 0.718 | 0.819 | 0.258 | 0.182 | 2.050 |

Fig 1.9: Countries That have a higher score than 7.5

## 4.2 For the filtered dataset - Sort the dataset by GDP per Capita in descending order and display the top 10 rows.

| | Country name | score | Log GDP per capita | Social support | Healthy life expectancy | Freedom to make life choices | Generosity | Perceptions of corruption | Dystopia + residual |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Denmark | 7.583 | 1.908 | 1.520 | 0.699 | 0.823 | 0.204 | 0.548 | 1.881 |
| 2 | Iceland | 7.525 | 1.881 | 1.617 | 0.718 | 0.819 | 0.258 | 0.182 | 2.050 |
| 0 | Finland | 7.741 | 1.844 | 1.572 | 0.695 | 0.859 | 0.142 | 0.546 | 2.082 |

Fig 2.0: Image of the filtered countries sorted by GDP in descending order

---

## 5.1 Create a new column called Happiness Category that categorizes countries into three categories based on their Score:

Low – (Score < 4)
Medium – (4 ≤ Score ≤ 6)
High – (Score > 6)

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | ... | 133 | 134 | 135 | 136 | 137 | 138 | 139 | 140 | 141 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Country name** | Finland | Denmark | Iceland | Sweden | Israel | Netherlands | Norway | Luxembourg | Switzerland | Australia | ... | Zambia | Eswatini | Malawi | Botswana | Zimbabwe | Congo (Kinshasa) | Sierra Leone | Lesotho | Lebanon |
| **score** | 7.741 | 7.583 | 7.525 | 7.344 | 7.341 | 7.319 | 7.302 | 7.122 | 7.06 | 7.057 | ... | 3.502 | 3.502 | 3.421 | 3.383 | 3.341 | 3.295 | 3.245 | 3.186 | 2.707 |
| **Log GDP per capita** | 1.844 | 1.908 | 1.881 | 1.878 | 1.803 | 1.901 | 1.952 | 2.141 | 1.97 | 1.854 | ... | 0.899 | 1.255 | 0.617 | 1.445 | 0.748 | 0.534 | 0.654 | 0.771 | 1.377 |
| **Social support** | 1.572 | 1.52 | 1.617 | 1.501 | 1.513 | 1.462 | 1.517 | 1.355 | 1.425 | 1.461 | ... | 0.809 | 0.925 | 0.41 | 0.969 | 0.85 | 0.665 | 0.566 | 0.851 | 0.577 |
| **Healthy life expectancy** | 0.695 | 0.699 | 0.718 | 0.724 | 0.74 | 0.706 | 0.704 | 0.708 | 0.747 | 0.692 | ... | 0.264 | 0.176 | 0.349 | 0.241 | 0.232 | 0.262 | 0.253 | 0.0 | 0.556 |
| **Freedom to make life choices** | 0.859 | 0.823 | 0.819 | 0.838 | 0.641 | 0.725 | 0.835 | 0.801 | 0.759 | 0.756 | ... | 0.727 | 0.284 | 0.571 | 0.567 | 0.487 | 0.473 | 0.469 | 0.523 | 0.173 |
| **Generosity** | 0.142 | 0.204 | 0.258 | 0.221 | 0.153 | 0.247 | 0.224 | 0.146 | 0.173 | 0.225 | ... | 0.168 | 0.059 | 0.135 | 0.014 | 0.096 | 0.189 | 0.181 | 0.082 | 0.068 |
| **Perceptions of corruption** | 0.546 | 0.548 | 0.182 | 0.524 | 0.193 | 0.372 | 0.484 | 0.432 | 0.498 | 0.323 | ... | 0.109 | 0.116 | 0.136 | 0.082 | 0.131 | 0.072 | 0.053 | 0.085 | 0.029 |
| **Dystopia + residual** | 2.082 | 1.881 | 2.05 | 1.658 | 2.298 | 1.906 | 1.586 | 1.54 | 1.488 | 1.745 | ... | 0.526 | 0.686 | 1.203 | 0.066 | 0.797 | 1.102 | 1.068 | 0.875 | -0.073 |
| **Happiness_Category** | High | High | High | High | High | High | High | High | High | High | ... | Low | Low | Low | Low | Low | Low | Low | Low | Low |

10 rows × 143 columns

Fig 2.1: Image after creating a new column Happiness_Category

After counting, it is observed that 56 countries fell in the High category, 17 in the low, and a majority of 70 in the medium category. This suggests that most countries are positioned in the middle range.

---

## 6.1 Bar Plot: Plot the top 10 happiest countries by Score using a bar chart.

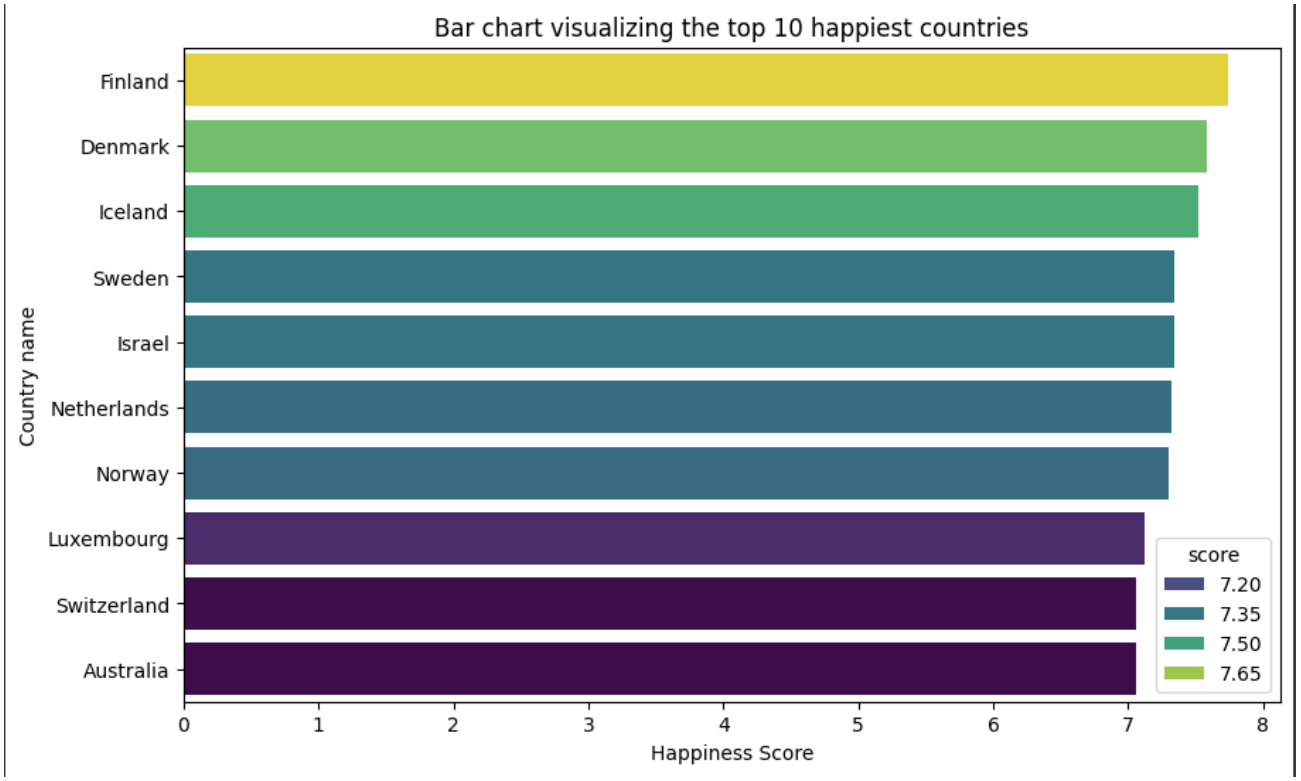



Fig 2.2: Result of plotting the top 10 happiest countries in a bar chart

## 6.2 Line Plot: Plot the top 10 unhappiest countries by Score using a Line chart

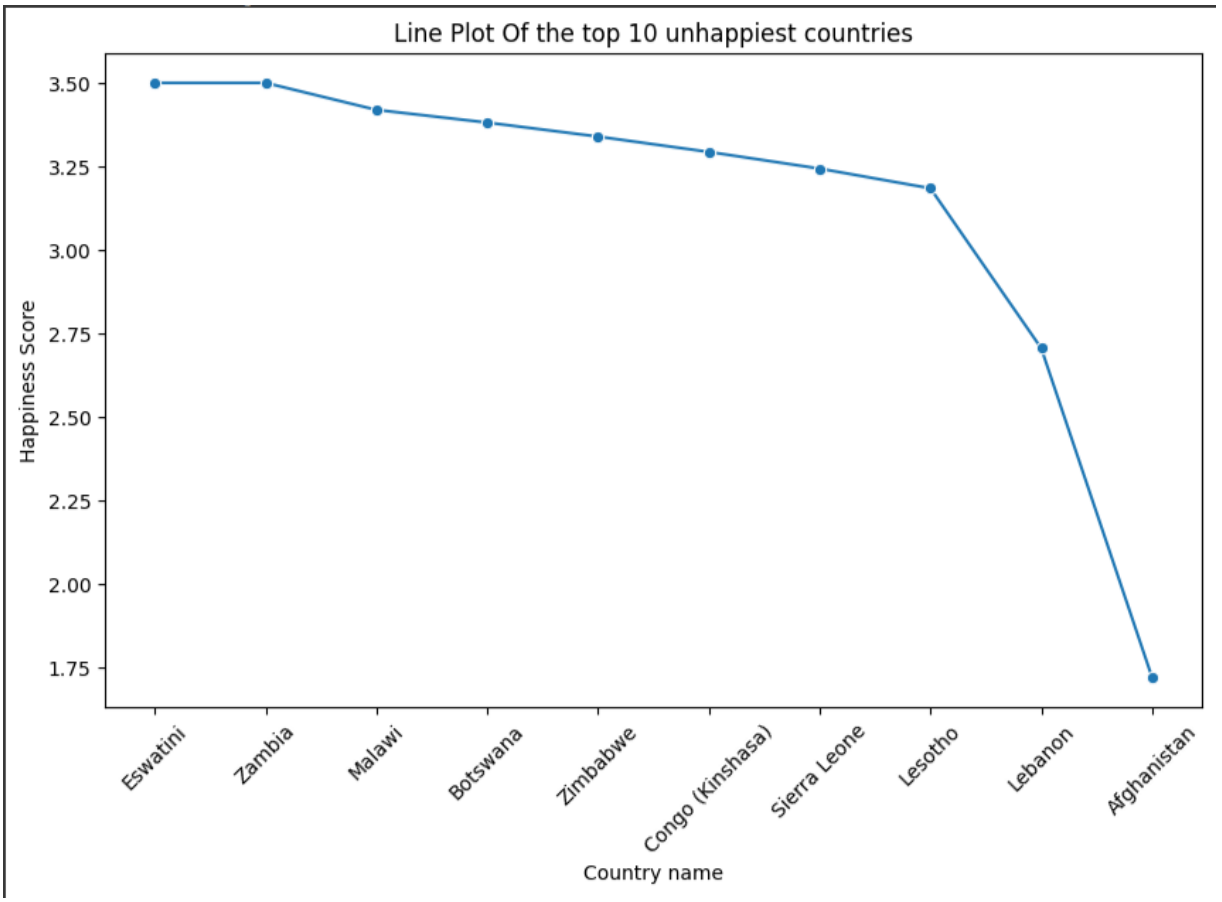



Fig 2.3: A Line Plot of the least 10 happiest countries.

The results indicate that the unhappiest countries almost all have a similar unhappiness score and a few have drastically low happiness scores.

## 6.3 Plot a histogram for the Score column to show its distribution and also interpret

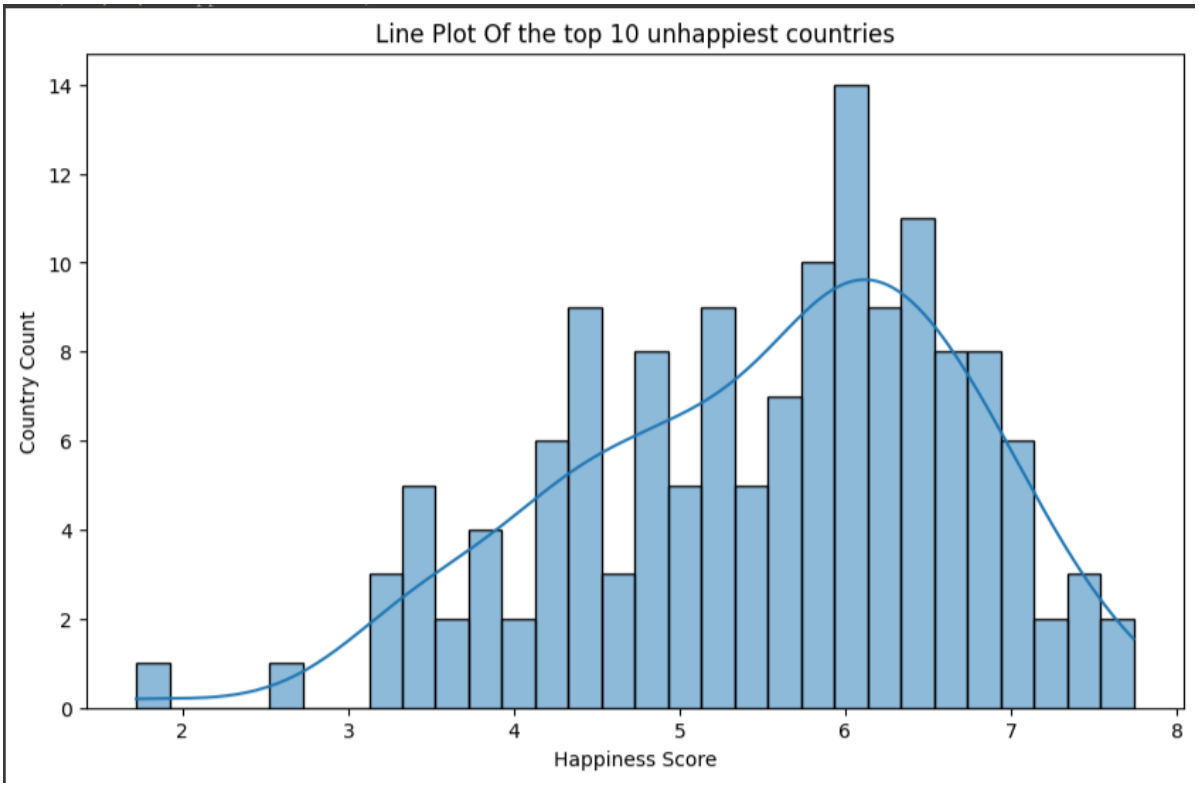



Fig 2.4: Histogram showing the distribution of the score column.

This visualization further solidifies our interpretation of the skewed distribution of the dataset. The data seems to be unimodal with a peak to the right, indicating a left skewed distribution.

## 6.4 Scatter Plot: Plot a scatter plot between GDP per Capita and Score to visualize their relationship

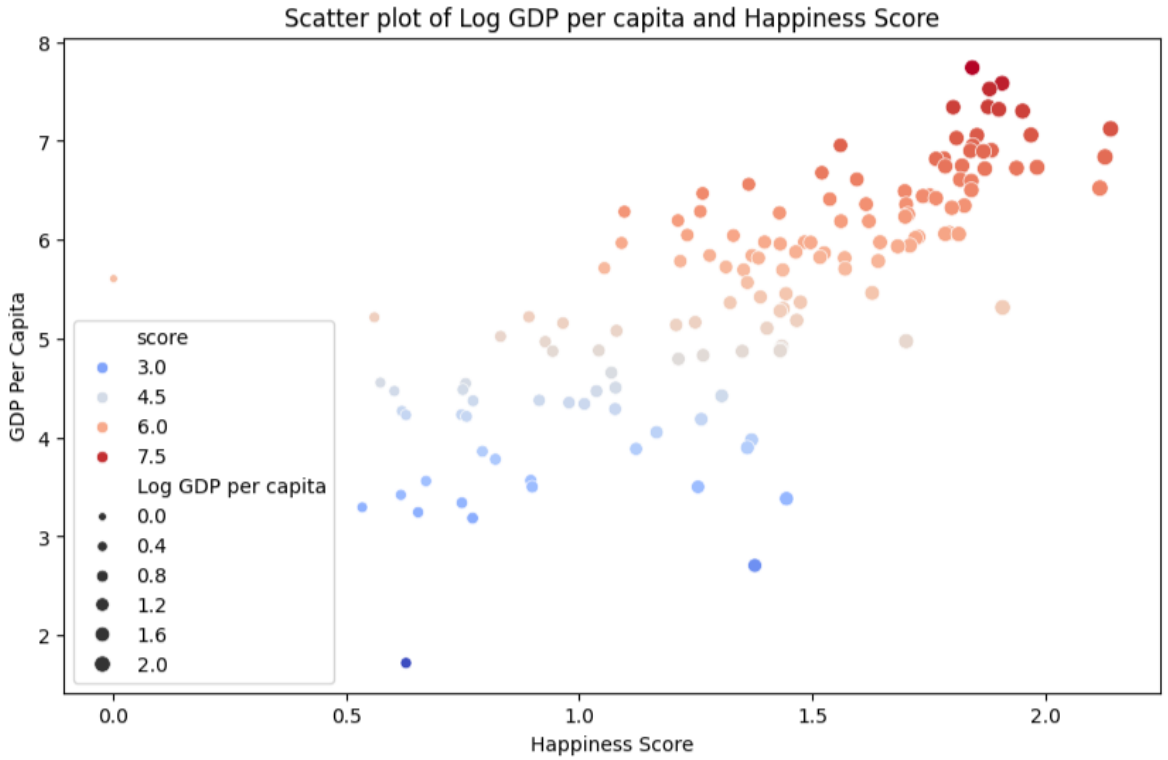



Fig 2.5: A scatter plot between GDP per capita and Score.

The data clearly indicates a positive correlation between these variables. It shows that the countries that are happier on average are also the ones with the highest gdp per capita. Majority of the data points are clustered toward the middle and upper spectrum of both axes, which suggests that most countries have a moderate to high happiness and GDP scores.

# Problem - 2 - Some Advance Data Exploration Task:

## 1.1 Define the countries in South Asia with a list for example

```
south_asian_countries = ["Afghanistan", "Bangladesh", "Bhutan", "India", "Maldives", "Nepal", "Pakistan", "Srilanka"]
```


```
south_asian_countries = ["Afghanistan", "Bangladesh", "Bhutan", "India", "Maldives", "Nepal", "Pakistan", "Srilanka"]
```


Fig 2.6: Declaring the countries in South Asia in a list.

## 1.2 Use the list from step - 1 to filter the dataset {i.e. filtered out matching dataset from list.}

| | Country name | score | Log GDP per capita | Social support | Healthy life expectancy | Freedom to make life choices | Generosity | Perceptions of corruption | Dystopia + residual | Happiness_Category |
|---|---|---|---|---|---|---|---|---|---|---|
| 92 | Nepal | 5.158 | 0.965 | 0.990 | 0.443 | 0.653 | 0.209 | 0.115 | 1.783 | Medium |
| 107 | Pakistan | 4.657 | 1.069 | 0.600 | 0.321 | 0.542 | 0.144 | 0.074 | 1.907 | Medium |
| 125 | India | 4.054 | 1.166 | 0.653 | 0.417 | 0.767 | 0.174 | 0.122 | 0.756 | Medium |
| 128 | Bangladesh | 3.886 | 1.122 | 0.249 | 0.513 | 0.775 | 0.140 | 0.167 | 0.919 | Low |
| 142 | Afghanistan | 1.721 | 0.628 | 0.000 | 0.242 | 0.000 | 0.091 | 0.088 | 0.672 | Low |

Fig 2.7: Image of the data frame containing South Asian Countries filtered from the original dataset

The results indicate that only 5 out of the 8 countries are present in the dataset. To address the missing countries, the values were calculated with the median of the dataset. While this doesn't accurately represent the actual situation in those countries, it merely serves as a strategy to counter the missing values.

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| **Country name** | Nepal | Pakistan | India | Bangladesh | Afghanistan | Bhutan | Maldives | Srilanka |
| **score** | 5.158 | 4.657 | 4.054 | 3.886 | 1.721 | 4.054 | 4.054 | 4.054 |
| **Log GDP per capita** | 0.965 | 1.069 | 1.166 | 1.122 | 0.628 | 1.069 | 1.069 | 1.069 |
| **Social support** | 0.99 | 0.6 | 0.653 | 0.249 | 0.0 | 0.6 | 0.6 | 0.6 |
| **Healthy life expectancy** | 0.443 | 0.321 | 0.417 | 0.513 | 0.242 | 0.417 | 0.417 | 0.417 |
| **Freedom to make life choices** | 0.653 | 0.542 | 0.767 | 0.775 | 0.0 | 0.653 | 0.653 | 0.653 |
| **Generosity** | 0.209 | 0.144 | 0.174 | 0.14 | 0.091 | 0.144 | 0.144 | 0.144 |
| **Perceptions of corruption** | 0.115 | 0.074 | 0.122 | 0.167 | 0.088 | 0.115 | 0.115 | 0.115 |
| **Dystopia + residual** | 1.783 | 1.907 | 0.756 | 0.919 | 0.672 | 0.919 | 0.919 | 0.919 |
| **Happiness_Category** | Medium | Medium | Medium | Low | Low | Medium | Medium | Medium |

Fig 2.8: Image after filling the values for the missing countries.

Description of the dataset:

| | score | Log GDP per capita | Social support | Healthy life expectancy | Freedom to make life choices | Generosity | Perceptions of corruption | Dystopia + residual |
|---|---|---|---|---|---|---|---|---|
| **count** | 8.000000 | 8.000000 | 8.000000 | 8.000000 | 8.000000 | 8.000000 | 8.000000 | 8.000000 |
| **mean** | 3.954750 | 1.019625 | 0.536500 | 0.398375 | 0.587000 | 0.148750 | 0.113875 | 1.099250 |
| **std** | 0.998194 | 0.168189 | 0.294194 | 0.081904 | 0.248355 | 0.033316 | 0.027132 | 0.470607 |
| **min** | 1.721000 | 0.628000 | 0.000000 | 0.242000 | 0.000000 | 0.091000 | 0.074000 | 0.672000 |
| **25%** | 4.012000 | 1.043000 | 0.512250 | 0.393000 | 0.625250 | 0.143000 | 0.108250 | 0.878250 |
| **50%** | 4.054000 | 1.069000 | 0.600000 | 0.417000 | 0.653000 | 0.144000 | 0.115000 | 0.919000 |
| **75%** | 4.204750 | 1.082250 | 0.613250 | 0.423500 | 0.681500 | 0.151500 | 0.116750 | 1.135000 |
| **max** | 5.158000 | 1.166000 | 0.990000 | 0.513000 | 0.775000 | 0.209000 | 0.167000 | 1.907000 |

## 1.3 Save the filtered data frame as separate CSV files for future use

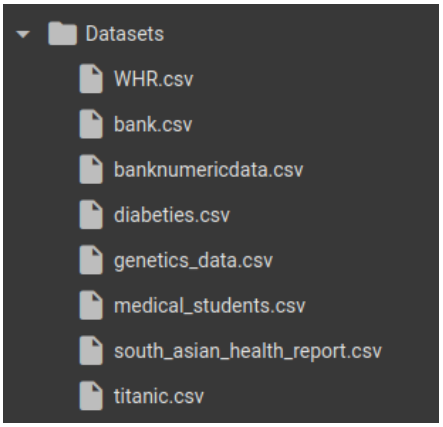



Fig 2.9: Image of the file tree where the data frame was stored as a CSV.

---

## 2.1 Using the SouthAsia DataFrame, create a new column called Composite Score that combines the following metrics

```
Composite Score = 0.40 × GDP per Capita + 0.30 × Social Support + 0.30 × Healthy Life Expectancy
```

| | Country name | Composite Score |
|---|---|---|
| 0 | Nepal | 0.8159 |
| 1 | Pakistan | 0.7039 |
| 2 | India | 0.7874 |
| 3 | Bangladesh | 0.6774 |
| 4 | Afghanistan | 0.3238 |
| 5 | Bhutan | 0.7327 |
| 6 | Maldives | 0.7327 |
| 7 | Srilanka | 0.7327 |

Fig 3.0: Results of creating the Composite Score column

While the same composite scores for Bhutan, Maldives, and Sri Lanka may raise concerns, this is expected, as the missing values for these countries were missing in the original dataset and later estimated using the median.

## 2.2 Rank the South Asian countries based on the Composite Score in descending order

| | Country name | score | Log GDP per capita | Social support | Healthy life expectancy | Freedom to make life choices | Generosity | Perceptions of corruption | Dystopia + residual | Happiness_Category | Composite Score |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | Nepal | 5.158 | 0.965 | 0.990 | 0.443 | 0.653 | 0.209 | 0.115 | 1.783 | Medium | 0.8159 |
| 2 | India | 4.054 | 1.166 | 0.653 | 0.417 | 0.767 | 0.174 | 0.122 | 0.756 | Medium | 0.7874 |
| 5 | Bhutan | 4.054 | 1.069 | 0.600 | 0.417 | 0.653 | 0.144 | 0.115 | 0.919 | Medium | 0.7327 |
| 6 | Maldives | 4.054 | 1.069 | 0.600 | 0.417 | 0.653 | 0.144 | 0.115 | 0.919 | Medium | 0.7327 |
| 7 | Srilanka | 4.054 | 1.069 | 0.600 | 0.417 | 0.653 | 0.144 | 0.115 | 0.919 | Medium | 0.7327 |
| 1 | Pakistan | 4.657 | 1.069 | 0.600 | 0.321 | 0.542 | 0.144 | 0.074 | 1.907 | Medium | 0.7039 |
| 3 | Bangladesh | 3.886 | 1.122 | 0.249 | 0.513 | 0.775 | 0.140 | 0.167 | 0.919 | Low | 0.6774 |
| 4 | Afghanistan | 1.721 | 0.628 | 0.000 | 0.242 | 0.000 | 0.091 | 0.088 | 0.672 | Low | 0.3238 |

Fig 3.1: Result after ranking the South Asian Countries based off their Composite Score

2.3 Visualize the top 5 countries using a horizontal bar chart showing the Composite Score.

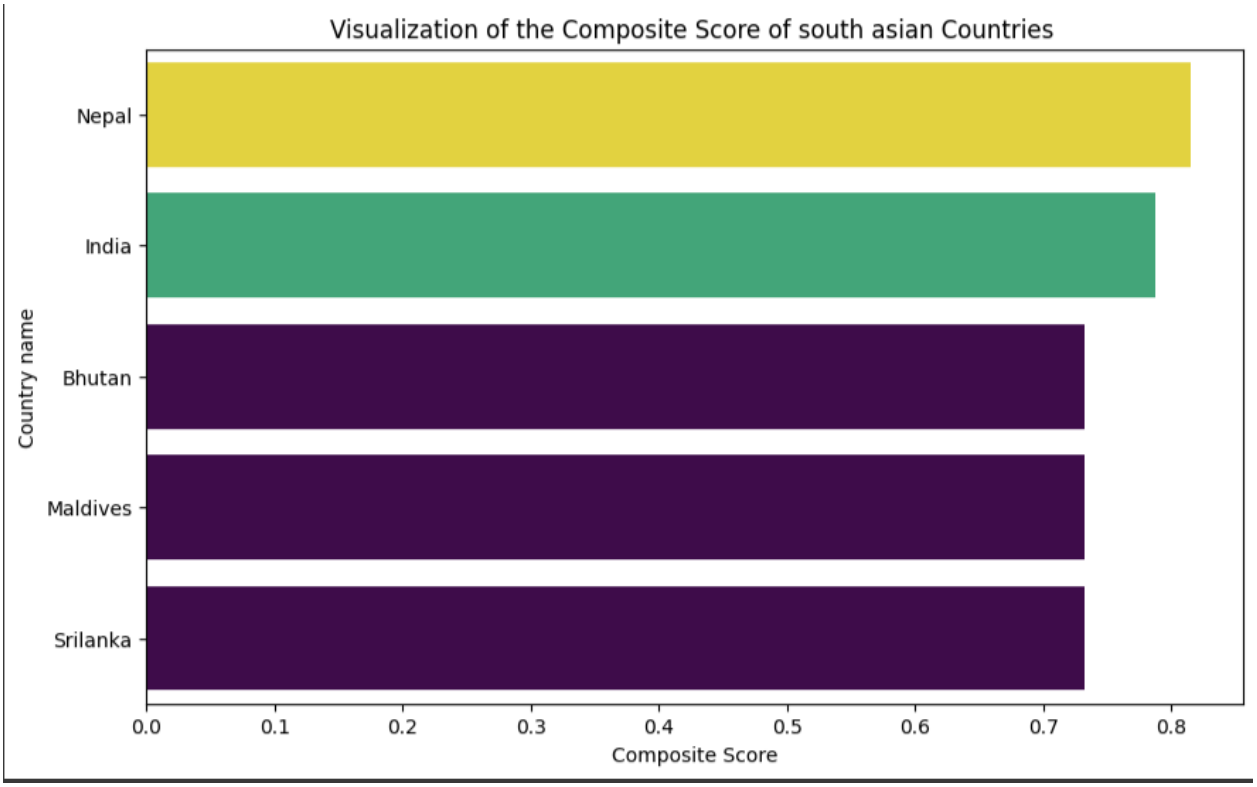
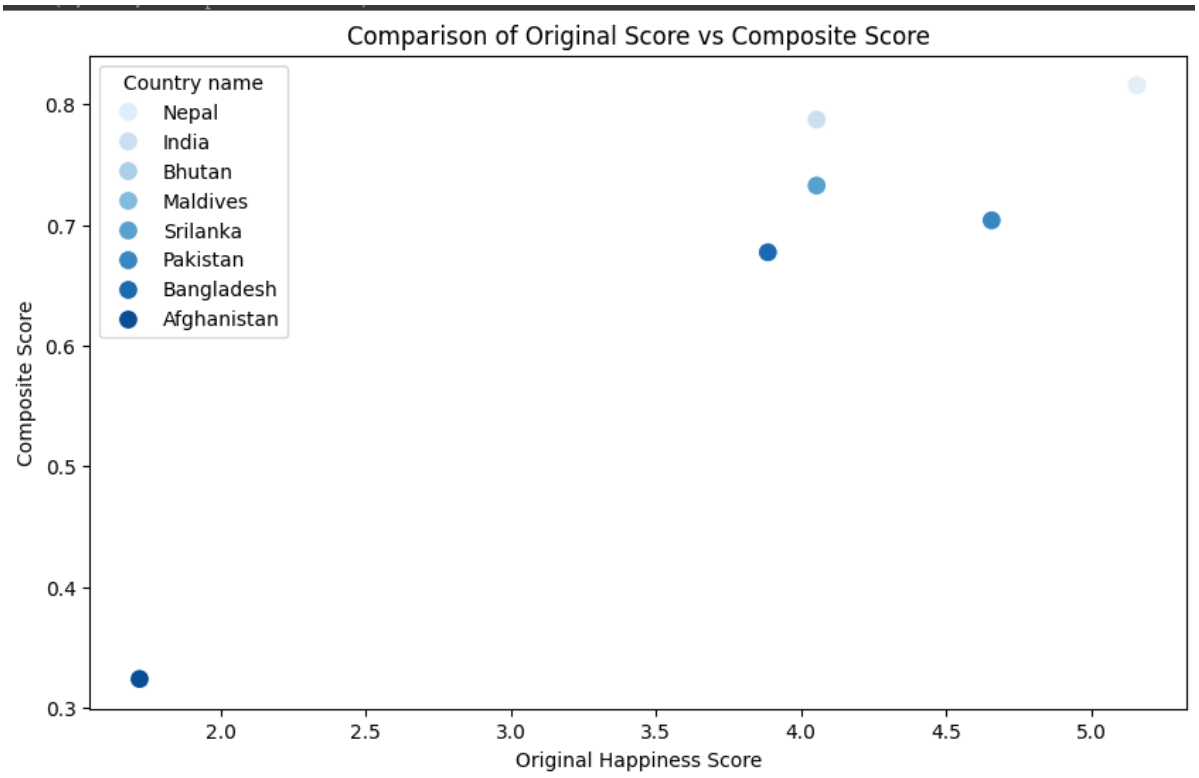



Fig 3.2: Visualization of the top 5 countries based on the composite score.

2.4 Discuss whether the rankings based on the Composite Score align with the original Score - support your discussion with some visualization plot




Both rankings have Nepal at the top, which shows that these two metrics align well at least for the highest ranked country. However, difference is seen from this point on, Pakistan which ranks 6th based off the Composite score ranks 2nd based on the original score. Bhutan, India, Maldives and Sri Lanka although have identical original scores, have different composite scores, which indicates that Composite Score weights the metrics differently.

The composite score considers factors such as GDP, Social support and Healthy Life expectancy which changes the rankings of some countries. This can imply that the Composite Score might give a nuanced picture compared to the original score.

---

## 3.1 Identify outlier countries in South Asia based on their Score and GDP per Capita

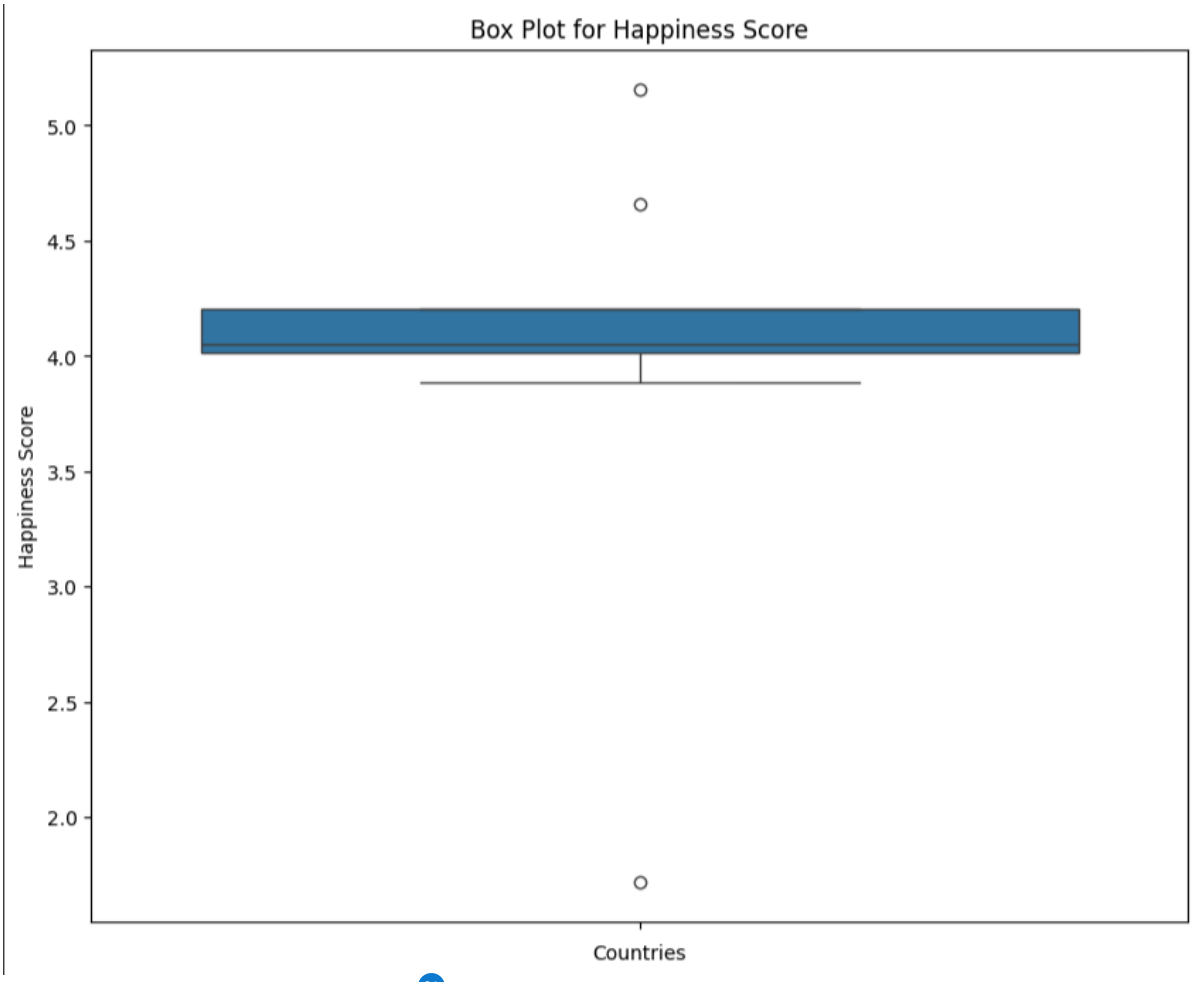



Fig 3.3: Box plot of the South Asian Countries based on their happiness scores

The result indicates that the median is much closer to the first quartile. The missing of the top whisker suggests that there are no values that extend the third quartile and the data is heavily skewed. The plot shows 3 outliers with 2 countries having exceptionally high happiness scores compared to the median, and a country having a very low happiness score. The majority of the countries have a happiness score hovering between ~4.0 - ~4.25 which suggests a low score for most countries.

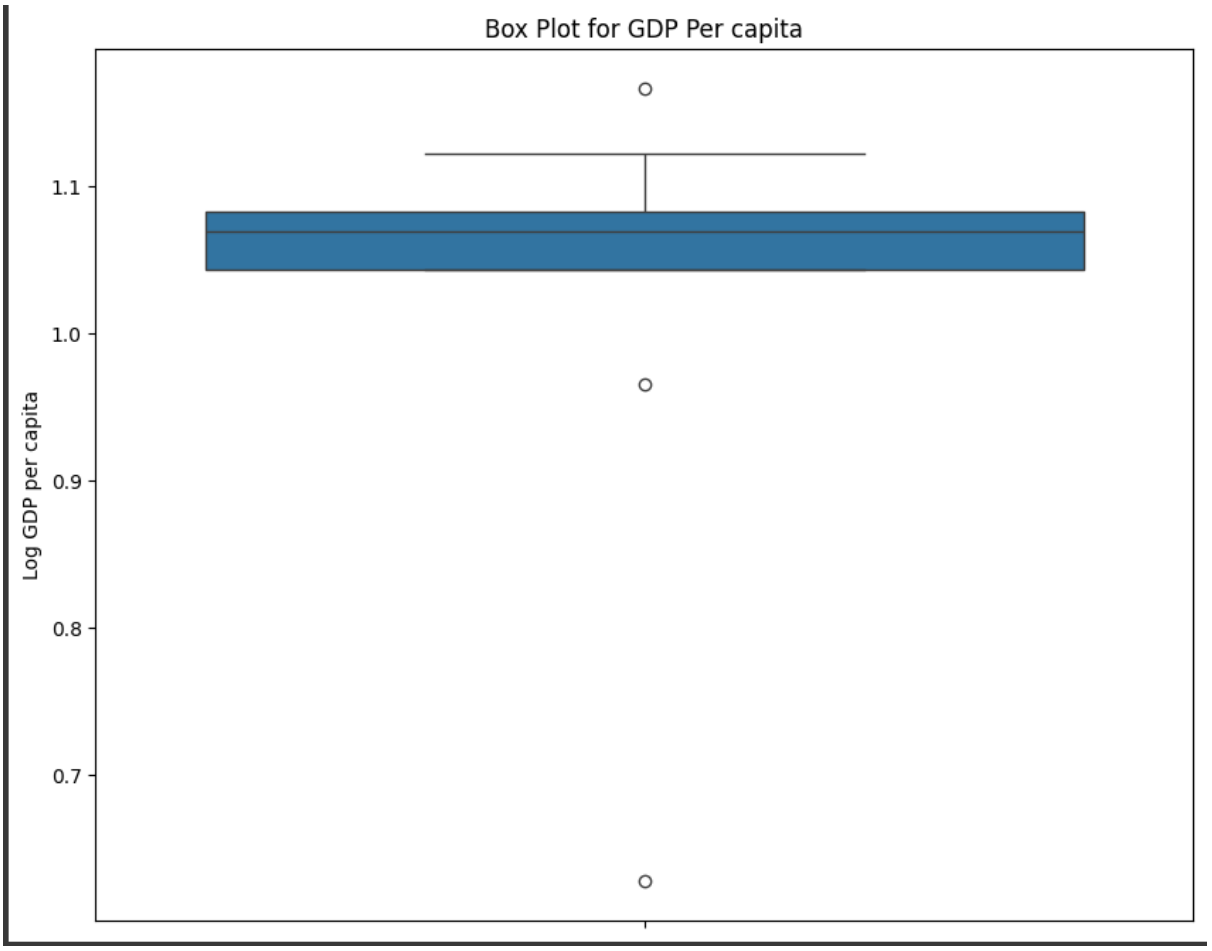



Fig 3.4: Box plot of the South Asian Countries based on their GDP per capita

Unlike the score, the median for `Log GDP per Capita` is closer to the 3rd quartile. The missing bottom whisker suggest that there are no values that extend the third quartile. The plot still shows 3 outliers, but majority fall under the 1.5 x iqr from q1, indicating much lower gdp per capita from the average, which ranges from ~1.05 - ~1.08

## 3.2 Define outliers using the 1.5 × IQR rule

| | Country name |
|---|---|
| 0 | Nepal |
| 2 | India |
| 4 | Afghanistan |

dtype: object

Fig 3.5: Image of all the outliers in the dataframe.

## 3.3 Create a scatter plot with GDP per Capita on the x-axis and Score on the y-axis, highlighting outliers in a different color

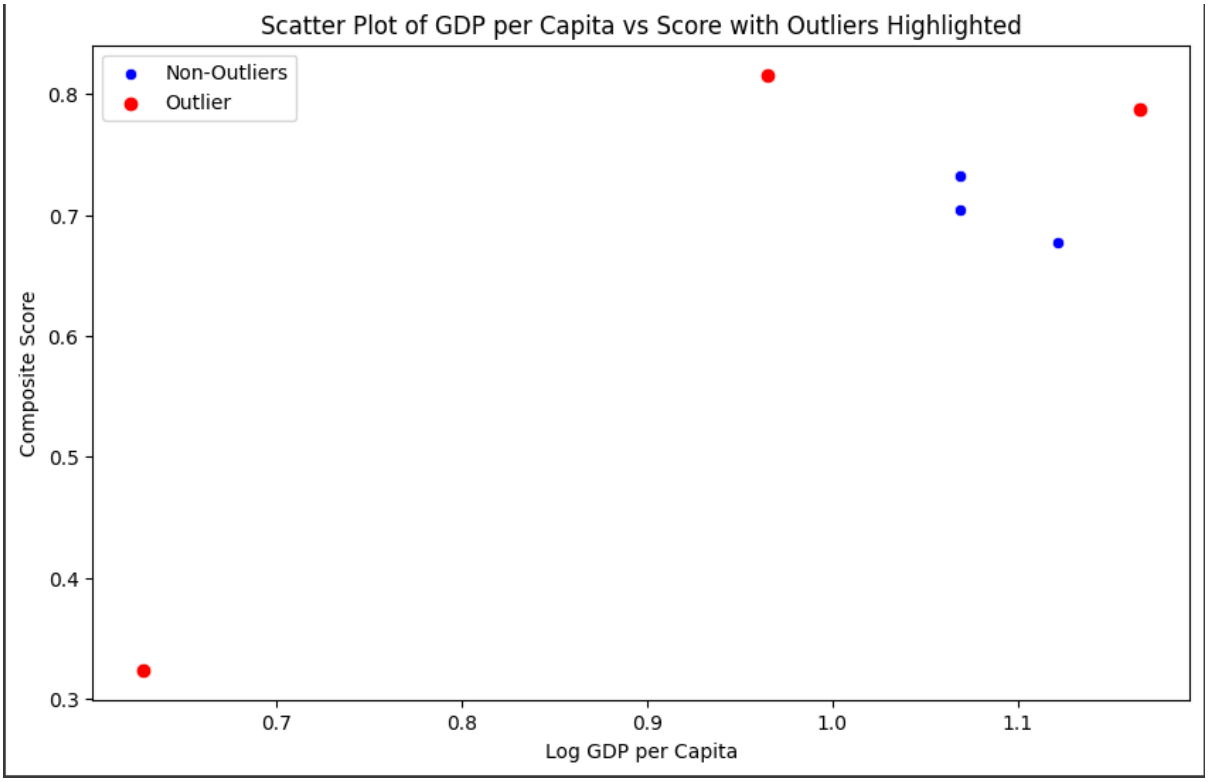



Fig 3.6: Scatter Plot of GDP and Happiness Scores with outliers highlighted.

The plot shows 3 outliers, Nepal, India and Afghanistan. Nepal and India are outliers since they have noticeably higher Composite score for their gdp per capita where as Afghanistan is exceptionally low in this scale

## 3.4 Discuss the characteristics of these outliers and their potential impact on regional averages

The outliers on the upper end of the spectrum are exceptionally high, whereas the one outlier on the lower end can pull down regional averages. These outliers skew the averages making the overall region seem happier or less happy than they truly are.

4.1. Choose two metrics (e.g., Freedom to Make Life Choices and Generosity) and calculate their correlation {pearson correlation} with the Score for South Asian countries.

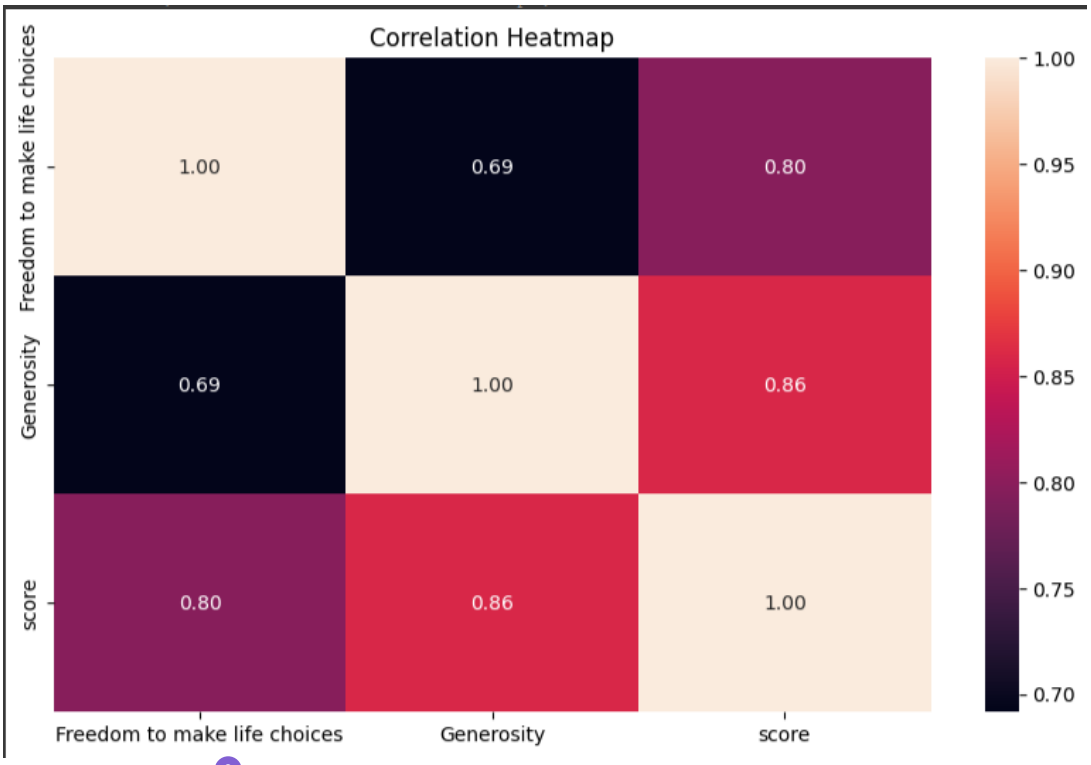



Fig 3.7: Correlation between the Happiness Score and the Freedom to Make Life Choices,Generosity.

4.2. Create scatter plots with trendlines for these metrics against the Score

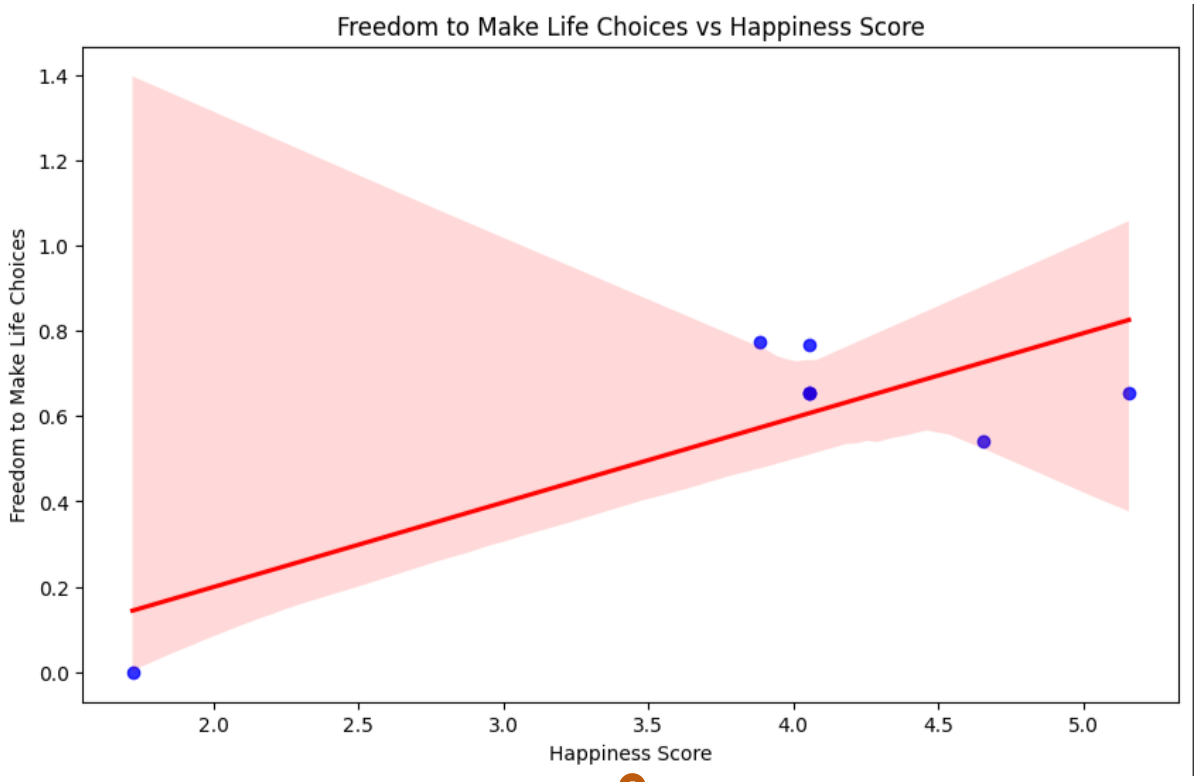



Fig 3.8: Scatter Plot With Trendlines for Happiness Score and Freedom To Make Life Choices.

As Happiness Score increases, the freedom to make life choices also increases, so there is a positive correlation between these two metrics. The confidence interval is largest at the lower points which suggests a big uncertainty, partly due to the fact that there are not enough data points around that region. Most of the data seems to be clustered towards the ~4.0 happiness score.

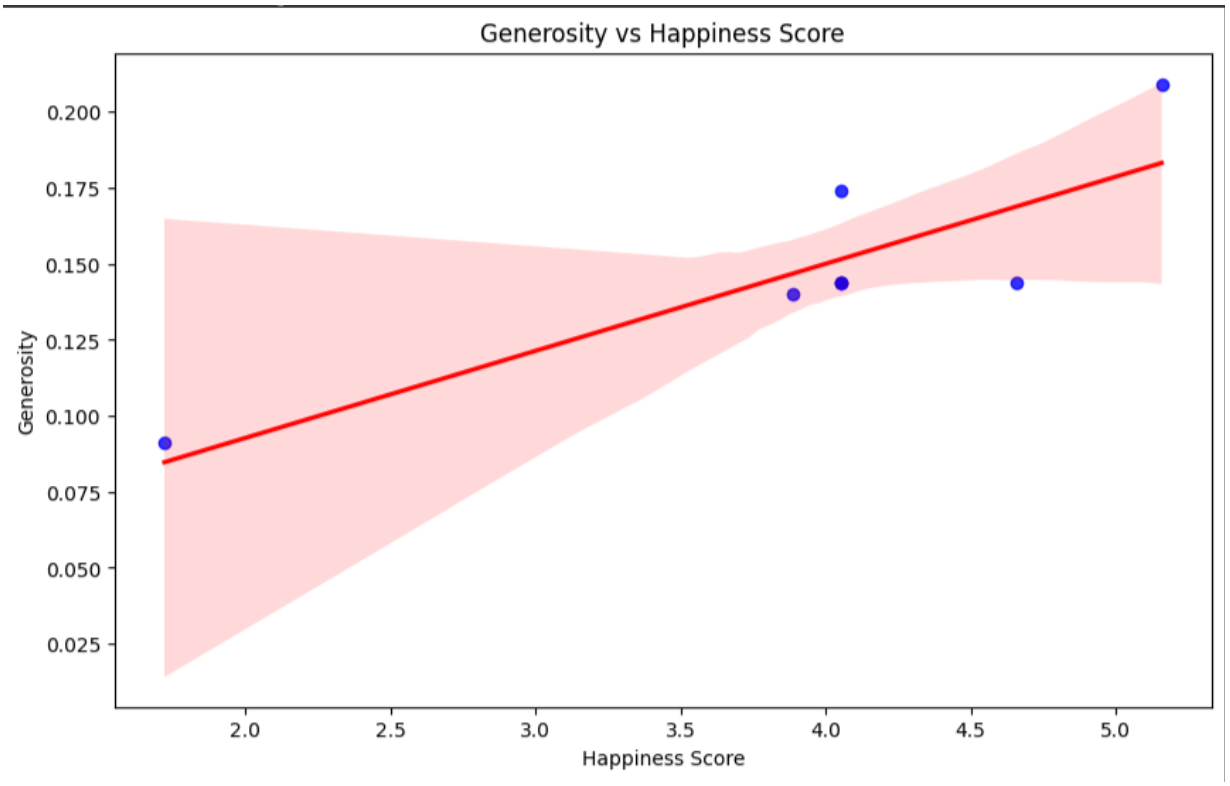



Fig 3.9: Scatter plot with trendlines for Happiness Score and Generosity

There also seems to be a positive correlation between the Happiness Score and Generosity. Similarly, the confidence interval is larger at the lower values which suggests variability, which also is partly due to the fact that there aren't enough points on that end of the spectrum. The data is also relatively clustered towards the ~4.0 happiness score.

## 4.3. Identify and discuss the strongest and weakest relationships between these metrics and the Score for South Asian countries.

Amongst Generosity and the Freedom to make life choices, Generosity seems to be more related with the Happiness Score for south asian countries. Although both these metrics have a strong correlation, Generosity seems to be a closer metric for happiness, which could reflect a deeper social and cultural bond amongst the South Asian countries. Freedom to make life choices while also having a strong relationship with the happiness, it suggests that South Asian countries value generosity more than the freedom to make their life choices

5.1. Add a new column, GDP-Score Gap, which is the difference between GDP per Capita and the Score for each South Asian country

| | 0 | 2 | 5 | 6 | 7 | 1 | 3 | 4 |
|---|---|---|---|---|---|---|---|---|
| **Country name** | Nepal | India | Bhutan | Maldives | Srilanka | Pakistan | Bangladesh | Afghanistan |
| **score** | 5.158 | 4.054 | 4.054 | 4.054 | 4.054 | 4.657 | 3.886 | 1.721 |
| **Log GDP per capita** | 0.965 | 1.166 | 1.069 | 1.069 | 1.069 | 1.069 | 1.122 | 0.628 |
| **Social support** | 0.99 | 0.653 | 0.6 | 0.6 | 0.6 | 0.6 | 0.249 | 0.0 |
| **Healthy life expectancy** | 0.443 | 0.417 | 0.417 | 0.417 | 0.417 | 0.321 | 0.513 | 0.242 |
| **Freedom to make life choices** | 0.653 | 0.767 | 0.653 | 0.653 | 0.653 | 0.542 | 0.775 | 0.0 |
| **Generosity** | 0.209 | 0.174 | 0.144 | 0.144 | 0.144 | 0.144 | 0.14 | 0.091 |
| **Perceptions of corruption** | 0.115 | 0.122 | 0.115 | 0.115 | 0.115 | 0.074 | 0.167 | 0.088 |
| **Dystopia + residual** | 1.783 | 0.756 | 0.919 | 0.919 | 0.919 | 1.907 | 0.919 | 0.672 |
| **Happiness_Category** | Medium | Medium | Medium | Medium | Medium | Medium | Low | Low |
| **Composite Score** | 0.8159 | 0.7874 | 0.7327 | 0.7327 | 0.7327 | 0.7039 | 0.6774 | 0.3238 |
| **GDP Score Gap** | -4.193 | -2.888 | -2.985 | -2.985 | -2.985 | -3.588 | -2.764 | -1.093 |

Fig 4.0: Result of adding the column GDP-Score gap

5.2. Rank the South Asian countries by this gap in both ascending and descending order.

| | Country name | score | Log GDP per capita | Social support | Healthy life expectancy | Freedom to make life choices | Generosity | Perceptions of corruption | Dystopia + residual | Happiness_Category | Composite Score | GDP Score Gap |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | Nepal | 5.158 | 0.965 | 0.990 | 0.443 | 0.653 | 0.209 | 0.115 | 1.783 | Medium | 0.8159 | -4.193 |
| 1 | Pakistan | 4.657 | 1.069 | 0.600 | 0.321 | 0.542 | 0.144 | 0.074 | 1.907 | Medium | 0.7039 | -3.588 |
| 5 | Bhutan | 4.054 | 1.069 | 0.600 | 0.417 | 0.653 | 0.144 | 0.115 | 0.919 | Medium | 0.7327 | -2.985 |
| 6 | Maldives | 4.054 | 1.069 | 0.600 | 0.417 | 0.653 | 0.144 | 0.115 | 0.919 | Medium | 0.7327 | -2.985 |
| 7 | Srilanka | 4.054 | 1.069 | 0.600 | 0.417 | 0.653 | 0.144 | 0.115 | 0.919 | Medium | 0.7327 | -2.985 |
| 2 | India | 4.054 | 1.166 | 0.653 | 0.417 | 0.767 | 0.174 | 0.122 | 0.756 | Medium | 0.7874 | -2.888 |
| 3 | Bangladesh | 3.886 | 1.122 | 0.249 | 0.513 | 0.775 | 0.140 | 0.167 | 0.919 | Low | 0.6774 | -2.764 |
| 4 | Afghanistan | 1.721 | 0.628 | 0.000 | 0.242 | 0.000 | 0.091 | 0.088 | 0.672 | Low | 0.3238 | -1.093 |
| | Country name | score | Log GDP per capita | Social support | Healthy life expectancy | Freedom to make life choices | Generosity | Perceptions of corruption | Dystopia + residual | Happiness_Category | Composite Score | GDP Score Gap |
| 4 | Afghanistan | 1.721 | 0.628 | 0.000 | 0.242 | 0.000 | 0.091 | 0.088 | 0.672 | Low | 0.3238 | -1.093 |
| 3 | Bangladesh | 3.886 | 1.122 | 0.249 | 0.513 | 0.775 | 0.140 | 0.167 | 0.919 | Low | 0.6774 | -2.764 |
| 2 | India | 4.054 | 1.166 | 0.653 | 0.417 | 0.767 | 0.174 | 0.122 | 0.756 | Medium | 0.7874 | -2.888 |
| 5 | Bhutan | 4.054 | 1.069 | 0.600 | 0.417 | 0.653 | 0.144 | 0.115 | 0.919 | Medium | 0.7327 | -2.985 |
| 6 | Maldives | 4.054 | 1.069 | 0.600 | 0.417 | 0.653 | 0.144 | 0.115 | 0.919 | Medium | 0.7327 | -2.985 |
| 7 | Srilanka | 4.054 | 1.069 | 0.600 | 0.417 | 0.653 | 0.144 | 0.115 | 0.919 | Medium | 0.7327 | -2.985 |
| 1 | Pakistan | 4.657 | 1.069 | 0.600 | 0.321 | 0.542 | 0.144 | 0.074 | 1.907 | Medium | 0.7039 | -3.588 |
| 0 | Nepal | 5.158 | 0.965 | 0.990 | 0.443 | 0.653 | 0.209 | 0.115 | 1.783 | Medium | 0.8159 | -4.193 |

Fig 4.1: Image after ranking the countries by both ascending and descending order based on the GDP-Score gap

## 5.3 Highlight the top 3 countries with the largest positive and negative gaps using a bar chart.

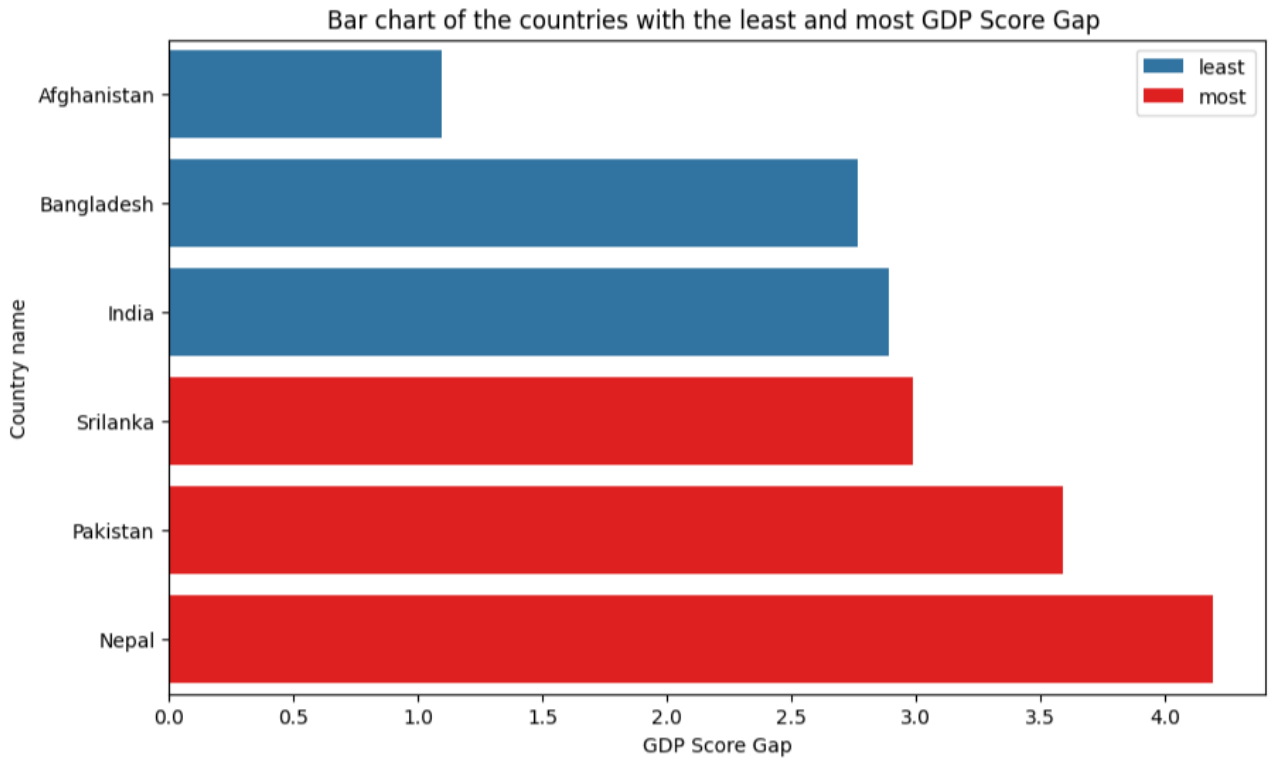



Fig 4.2: Countries with the largest and smallest GDP-Score gap.

## 5.4 Analyze the reasons behind these gaps and their implications for South Asian countries.

The GDP score gap helps us understand the difference between a country's GDP and its happiness score. Afghanistan having the lowest GDP per capita also has the lowest happiness score, which reflects the big challenges the country is facing. Nepal, although having a relatively low GDP, has a significantly higher happiness score, indicating that the country despite its financial troubles is still performing good in terms of happiness. Pakistan and Bangladesh have similar GDP scores, but noticeably different happiness scores. Bhutan, Maldives and Sri Lanka have the same scores which may raise concerns but its only due to the fact that their data were not present in the World Health Report but were rather imputed from the median. India's gap suggests that factors like social support and healthy life expectancy could be suffering

# Problem - 3 - Comparative Analysis:

## 1.1 Similar in Task - 1 of Problem 2 create a dataframe from middle eastern countries. For hint use the following list:

Description of the dataset:

| | score | Log GDP per capita | Social support | Healthy life expectancy | Freedom to make life choices | Generosity | Perceptions of corruption | Dystopia + residual |
|---|---|---|---|---|---|---|---|---|
| count | 14.000000 | 14.000000 | 14.000000 | 14.000000 | 14.000000 | 14.000000 | 14.000000 | 14.000000 |
| mean | 5.455071 | 1.473679 | 1.172536 | 0.555321 | 0.578429 | 0.139321 | 0.144536 | 1.441821 |
| std | 1.305064 | 0.328182 | 0.220213 | 0.096573 | 0.187109 | 0.050831 | 0.058561 | 0.641766 |
| min | 2.707000 | 0.671000 | 0.577000 | 0.293000 | 0.173000 | 0.059000 | 0.029000 | -0.073000 |
| 25% | 4.983750 | 1.390625 | 1.143000 | 0.551125 | 0.467000 | 0.119625 | 0.121125 | 1.203875 |
| 50% | 5.562500 | 1.433250 | 1.200750 | 0.559500 | 0.617000 | 0.138750 | 0.147500 | 1.692750 |
| 75% | 6.435250 | 1.711000 | 1.270125 | 0.569000 | 0.641000 | 0.150000 | 0.184000 | 1.777750 |
| max | 7.341000 | 1.983000 | 1.513000 | 0.740000 | 0.827000 | 0.235000 | 0.258000 | 2.298000 |

```
middle_east_countries = [ "Bahrain", "Iran", "Iraq", "Israel", "Jordan", "Kuwait", "Lebanon", "Oman", "Palestine", "Qatar", "Saudi Arabia", "Syria", "United Arab Emirates", "Yemen"]
```

| | Country name | score | Log GDP per capita | Social support | Healthy life expectancy | Freedom to make life choices | Generosity | Perceptions of corruption | Dystopia + residual | Happiness_Category |
|---|---|---|---|---|---|---|---|---|---|---|
| 4 | Israel | 7.341 | 1.8030 | 1.5130 | 0.7400 | 0.641 | 0.1530 | 0.1930 | 2.2980 | High |
| 12 | Kuwait | 6.951 | 1.8450 | 1.3640 | 0.6610 | 0.827 | 0.2000 | 0.1720 | 1.8840 | High |
| 21 | United Arab Emirates | 6.733 | 1.9830 | 1.1640 | 0.5630 | 0.815 | 0.2090 | 0.2580 | 1.7410 | High |
| 27 | Saudi Arabia | 6.594 | 1.8420 | 1.3610 | 0.5110 | 0.787 | 0.1140 | 0.1880 | 1.7900 | High |
| 61 | Bahrain | 5.959 | 1.4315 | 1.2375 | 0.5495 | 0.641 | 0.1365 | 0.1205 | 1.6445 | Medium |
| 91 | Iraq | 5.166 | 1.2490 | 0.9960 | 0.4980 | 0.425 | 0.1410 | 0.0480 | 1.8090 | Medium |
| 99 | Iran | 4.923 | 1.4350 | 1.1360 | 0.5710 | 0.366 | 0.2350 | 0.1230 | 1.0570 | Medium |
| 124 | Jordan | 4.186 | 1.2620 | 0.9830 | 0.5940 | 0.593 | 0.0590 | 0.1890 | 0.5040 | Medium |
| 132 | Yemen | 3.561 | 0.6710 | 1.2810 | 0.2930 | 0.362 | 0.0800 | 0.1130 | 0.7600 | Low |
| 141 | Lebanon | 2.707 | 1.3770 | 0.5770 | 0.5560 | 0.173 | 0.0680 | 0.0290 | -0.0730 | Low |

Fig 4.3: Filtered Dataset of only the Middle Eastern Countries from the original dataset.

The results indicate that only 10 out of the 14 countries are present in the dataset. To address the missing countries, the values were calculated with the median of the dataset. While this doesn't accurately represent the actual situation in those countries, it merely serves as a strategy to counter the missing values.

| | Country name | score | Log GDP per capita | Social support | Healthy life expectancy | Freedom to make life choices | Generosity | Perceptions of corruption | Dystopia + residual | Happiness_Category |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | Israel | 7.3410 | 1.80300 | 1.51300 | 0.7400 | 0.641 | 0.15300 | 0.1930 | 2.29800 | High |
| 1 | Kuwait | 6.9510 | 1.84500 | 1.36400 | 0.6610 | 0.827 | 0.20000 | 0.1720 | 1.88400 | High |
| 2 | United Arab Emirates | 6.7330 | 1.98300 | 1.16400 | 0.5630 | 0.815 | 0.20900 | 0.2580 | 1.74100 | High |
| 3 | Saudi Arabia | 6.5940 | 1.84200 | 1.36100 | 0.5110 | 0.787 | 0.11400 | 0.1880 | 1.79000 | High |
| 4 | Bahrain | 5.9590 | 1.43150 | 1.23750 | 0.5495 | 0.641 | 0.13650 | 0.1205 | 1.64450 | Medium |
| 5 | Iraq | 5.1660 | 1.24900 | 0.99600 | 0.4980 | 0.425 | 0.14100 | 0.0480 | 1.80900 | Medium |
| 6 | Iran | 4.9230 | 1.43500 | 1.13600 | 0.5710 | 0.366 | 0.23500 | 0.1230 | 1.05700 | Medium |
| 7 | Jordan | 4.1860 | 1.26200 | 0.98300 | 0.5940 | 0.593 | 0.05900 | 0.1890 | 0.50400 | Medium |
| 8 | Yemen | 3.5610 | 0.67100 | 1.28100 | 0.2930 | 0.362 | 0.08000 | 0.1130 | 0.76000 | Low |
| 9 | Lebanon | 2.7070 | 1.37700 | 0.57700 | 0.5560 | 0.173 | 0.06800 | 0.0290 | -0.07300 | Low |
| 10 | Oman | 5.5625 | 1.43325 | 1.20075 | 0.5595 | 0.617 | 0.13875 | 0.1475 | 1.69275 | High |
| 11 | Palestine | 5.5625 | 1.43325 | 1.20075 | 0.5595 | 0.617 | 0.13875 | 0.1475 | 1.69275 | High |
| 12 | Qatar | 5.5625 | 1.43325 | 1.20075 | 0.5595 | 0.617 | 0.13875 | 0.1475 | 1.69275 | High |
| 13 | Syria | 5.5625 | 1.43325 | 1.20075 | 0.5595 | 0.617 | 0.13875 | 0.1475 | 1.69275 | High |

Fig 4.4: Updated Dataset of the Middle Eastern Countries with missing countries imputed.

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## 2.1 Calculate the mean, Standard deviation of the score for both South Asia and Middle East.

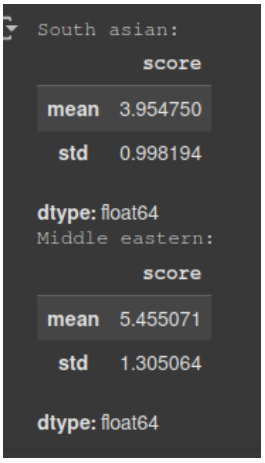


Fig 4.5: Result of Calculating the mean and standard deviation of both regions.

## 2.2 Which region has higher happiness Scores on average?

From the above results, we can conclude that Middle Eastern countries are happier on average than the South Asian countries.

## 3.1 Identify the top 3 and bottom 3 countries in each region based on the score.

| | Country name | score | Log GDP per capita | Social support | Healthy life expectancy | Freedom to make life choices | Generosity | Perceptions of corruption | Dystopia + residual | Happiness_Category | Composite Score | GDP Score Gap | Region |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | Nepal | 5.158 | 0.965 | 0.990 | 0.443 | 0.653 | 0.209 | 0.115 | 1.783 | Medium | 0.8159 | -4.193 | South Asian |
| 1 | Pakistan | 4.657 | 1.069 | 0.600 | 0.321 | 0.542 | 0.144 | 0.074 | 1.907 | Medium | 0.7039 | -3.588 | South Asian |
| 2 | India | 4.054 | 1.166 | 0.653 | 0.417 | 0.767 | 0.174 | 0.122 | 0.756 | Medium | 0.7874 | -2.888 | South Asian |
| 7 | Srilanka | 4.054 | 1.069 | 0.600 | 0.417 | 0.653 | 0.144 | 0.115 | 0.919 | Medium | 0.7327 | -2.985 | South Asian |
| 3 | Bangladesh | 3.886 | 1.122 | 0.249 | 0.513 | 0.775 | 0.140 | 0.167 | 0.919 | Low | 0.6774 | -2.764 | South Asian |
| 4 | Afghanistan | 1.721 | 0.628 | 0.000 | 0.242 | 0.000 | 0.091 | 0.088 | 0.672 | Low | 0.3238 | -1.093 | South Asian |

| | Country name | score | Log GDP per capita | Social support | Healthy life expectancy | Freedom to make life choices | Generosity | Perceptions of corruption | Dystopia + residual | Happiness_Category | Region |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | Israel | 7.341 | 1.803 | 1.513 | 0.740 | 0.641 | 0.153 | 0.193 | 2.298 | High | Middle Eastern |
| 1 | Kuwait | 6.951 | 1.845 | 1.364 | 0.661 | 0.827 | 0.200 | 0.172 | 1.884 | High | Middle Eastern |
| 2 | United Arab Emirates | 6.733 | 1.983 | 1.164 | 0.563 | 0.815 | 0.209 | 0.258 | 1.741 | High | Middle Eastern |
| 7 | Jordan | 4.186 | 1.262 | 0.983 | 0.594 | 0.593 | 0.059 | 0.189 | 0.504 | Medium | Middle Eastern |
| 8 | Yemen | 3.561 | 0.671 | 1.281 | 0.293 | 0.362 | 0.080 | 0.113 | 0.760 | Low | Middle Eastern |
| 9 | Lebanon | 2.707 | 1.377 | 0.577 | 0.556 | 0.173 | 0.068 | 0.029 | -0.073 | Low | Middle Eastern |

<Axes: xlabel='Country name', ylabel='score'>

Fig 4.6: Top and bottom 3 countries in each region based on the Happiness Score.

## 3.2 Plot bar charts comparing these charts.

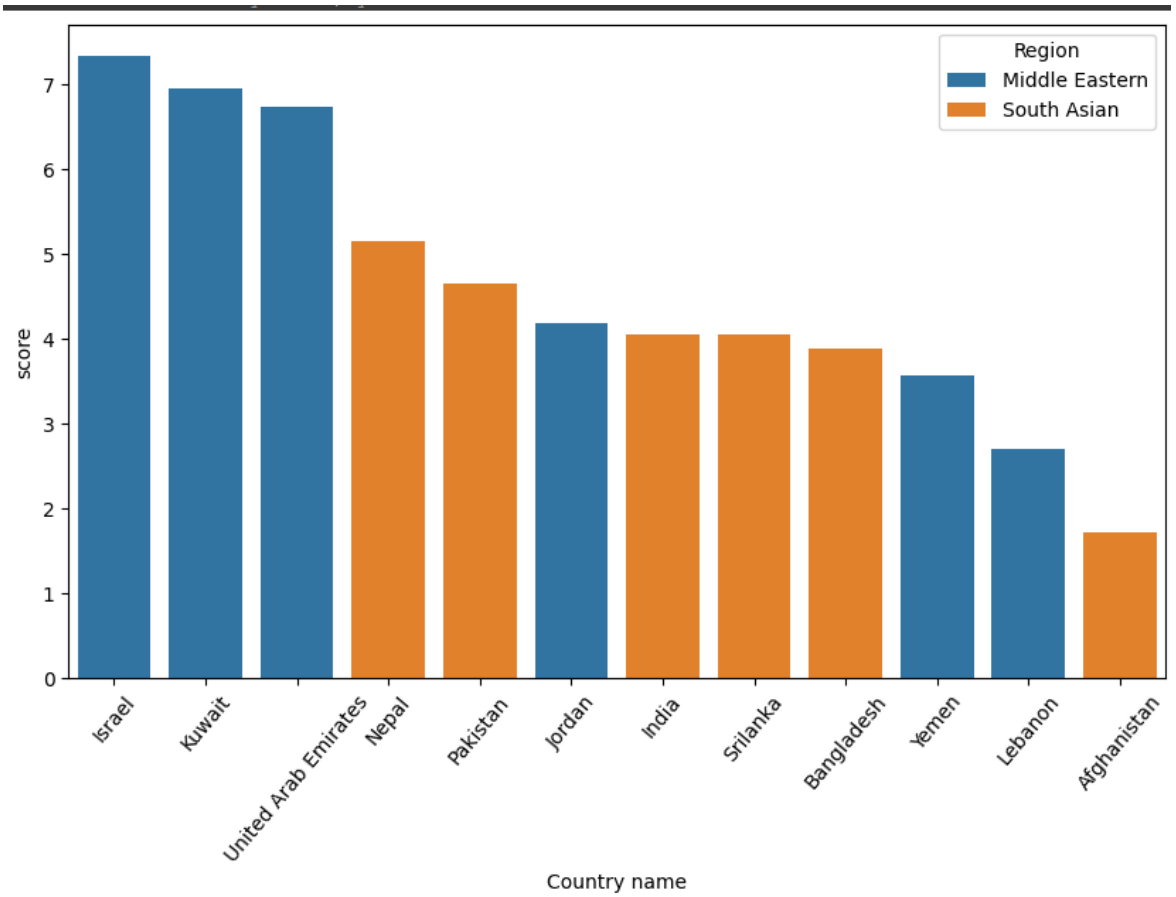


Fig 4.7: Bar plot comparing the three happiest and unhappiest countries in each region.

## 4.1 Compare key metrics like GDP per Capita, Social Support, and Healthy Life Expectancy between the regions using grouped bar charts.

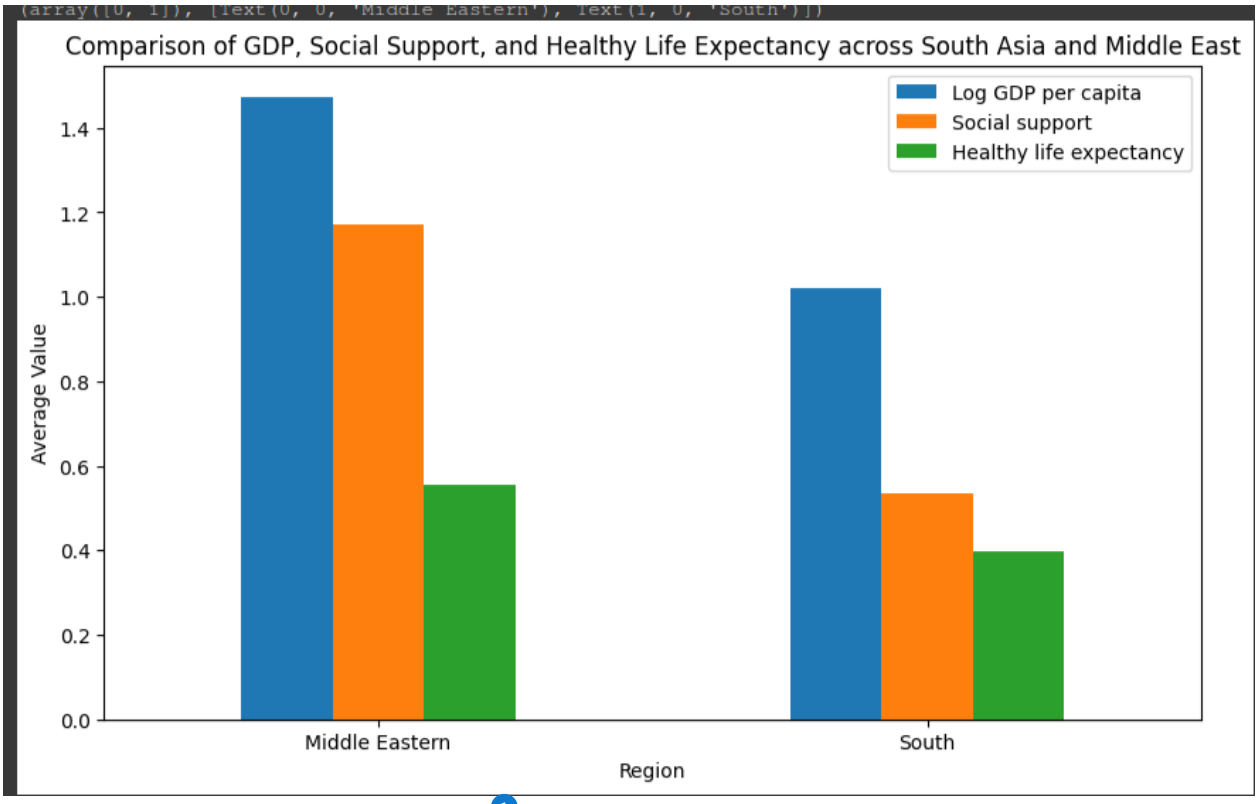


Fig 4.8: Bar chart grouped by region, comparing GDP per capita, Social Support and Healthy Life Expectancy between the regions.

| | |
|---|---|
| Log GDP per capita | 0.586688 |
| score | 2.026875 |
| Healthy life expectancy | 0.187562 |
| Social support | 0.682813 |

Fig 4.9: calculation of the gap between these metrics amongst these regions.

The chart shows that the Middle East is clearly better in every metric between these two regions. The difference in GDP is~ 0.58, the difference in Social support is ~0.68 and the difference between the Healthy life expectancy is only about ~0.18.

## 4.2 Which metrics show the largest disparity between the two regions?

The largest disparity can be seen with the Social support, with a disparity of ~0.68

---

## 5.1 Compute the range (max - min) and coefficient of variation (CV) for Score in both regions.

| | Region | Range | CV (%) |
|---|---|---|---|
| 0 | South Asia | 3.437 | 25.240372 |
| 1 | Middle East | 4.634 | 23.923870 |

Fig 5.0: Range and Coefficient of Variation for Happiness Score amongst the regions.

## 5.2 Which region has greater variability in happiness?

South Asia seems to have a greater variability in happiness.

---

## 6.1 Analyze the correlation of Score with other metrics Freedom to Make Life Choices, and Generosity within each region.

south asian:

| | score |
|---|---|
| score | 1.000000 |
| Freedom to make life choices | 0.797314 |
| Generosity | 0.858518 |

dtype: float64

middle eastern:

| | score |
|---|---|
| score | 1.000000 |
| Freedom to make life choices | 0.863386 |
| Generosity | 0.619213 |

dtype: float64

Fig 5.1: Correlation between the metrics

The results indicate that Generosity seems to be more correlated with the happiness score in the South Asian countries as compared to the Middle Eastern countries, while the opposite is true for the correlation between the freedom to make life choices and the happiness score between these two regions

## 6.2 Create scatter plots to visualize and interpret the relationships

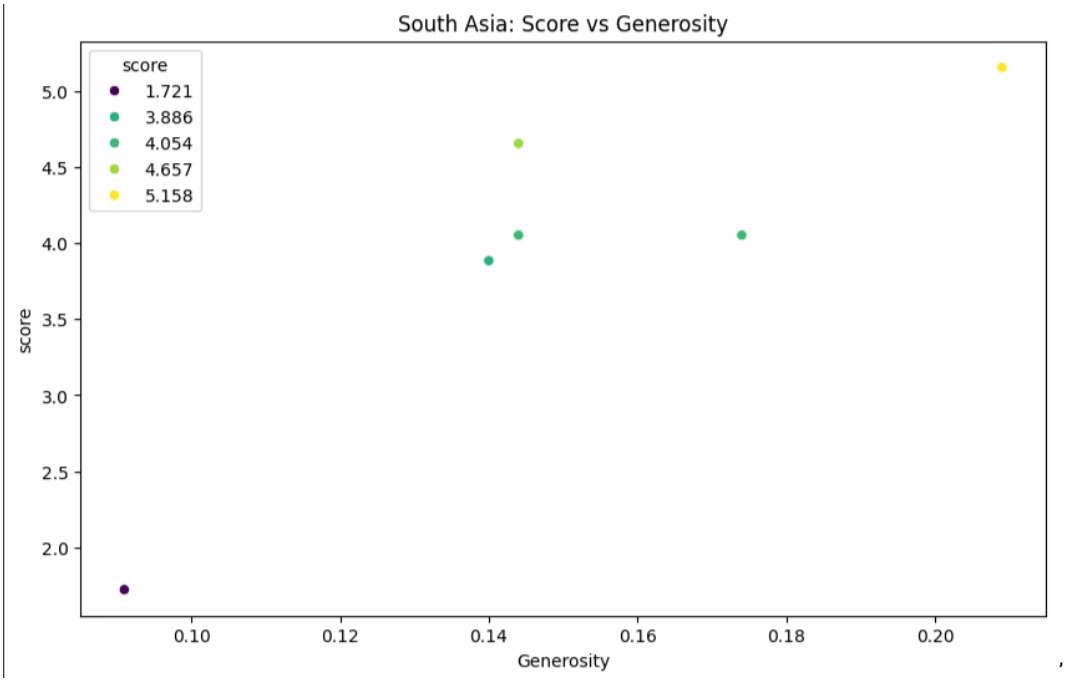


Fig 5.2: Scatter plot between Generosity and Happiness Scores For South Asia

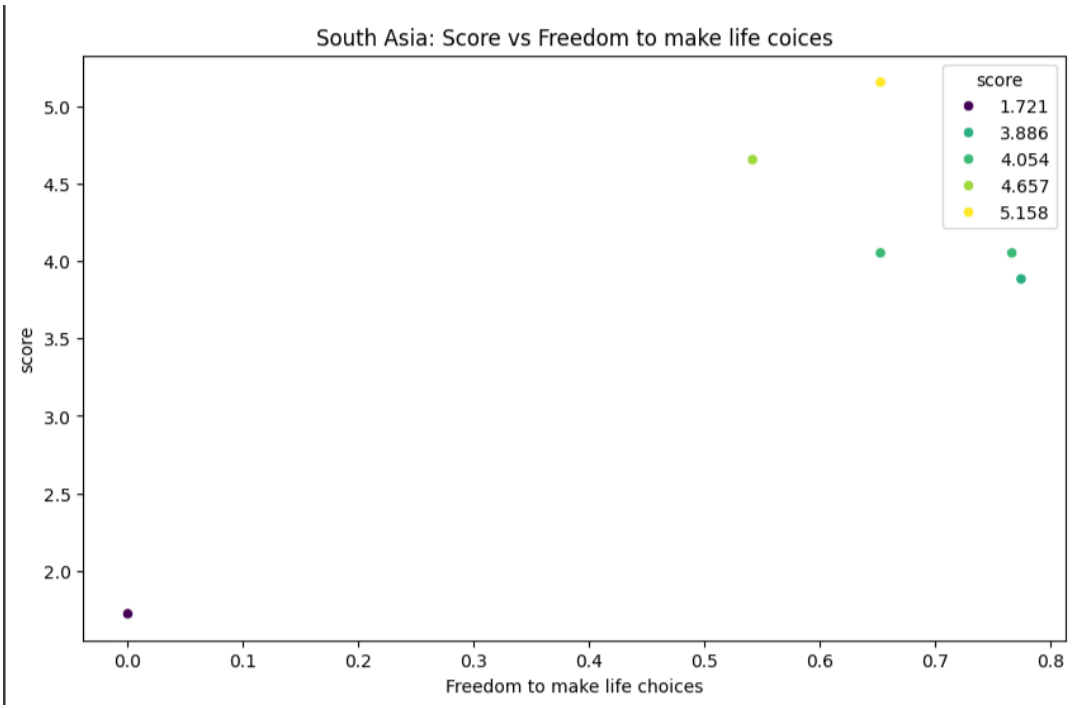


Fig 5.3: Scatter plot between Freedom to make life choices and Happiness Scores For South Asia

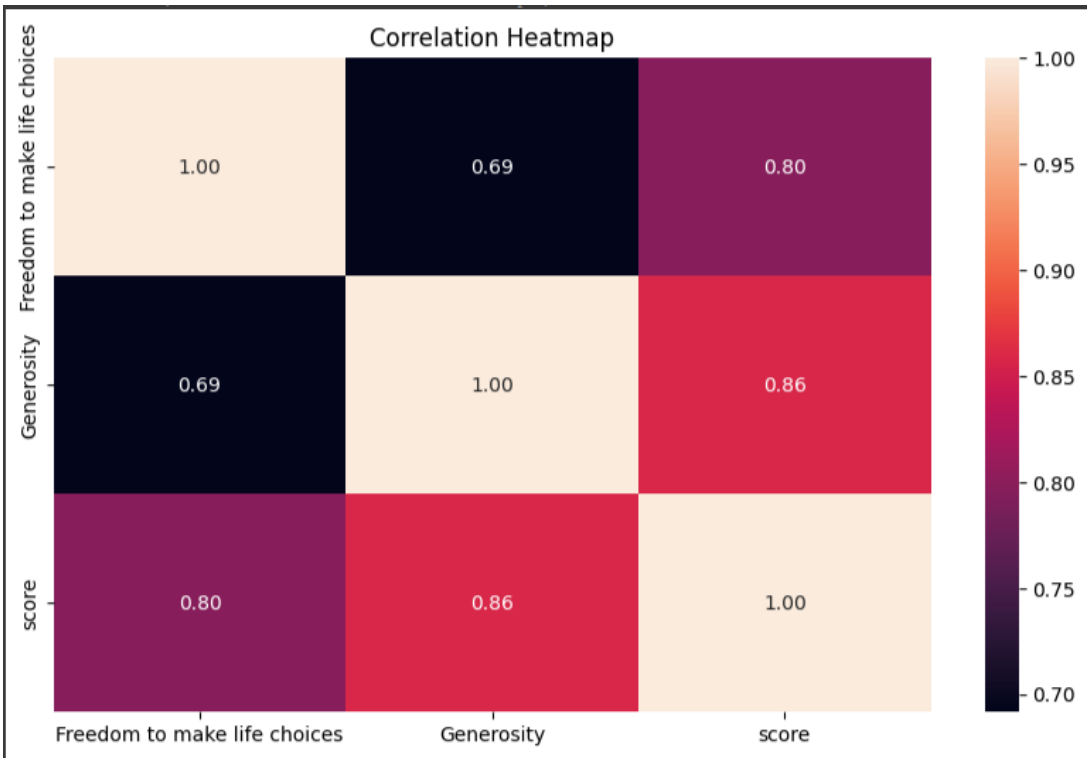


Fig 5.4: Heatmap of the correlations between these metrics for south asia

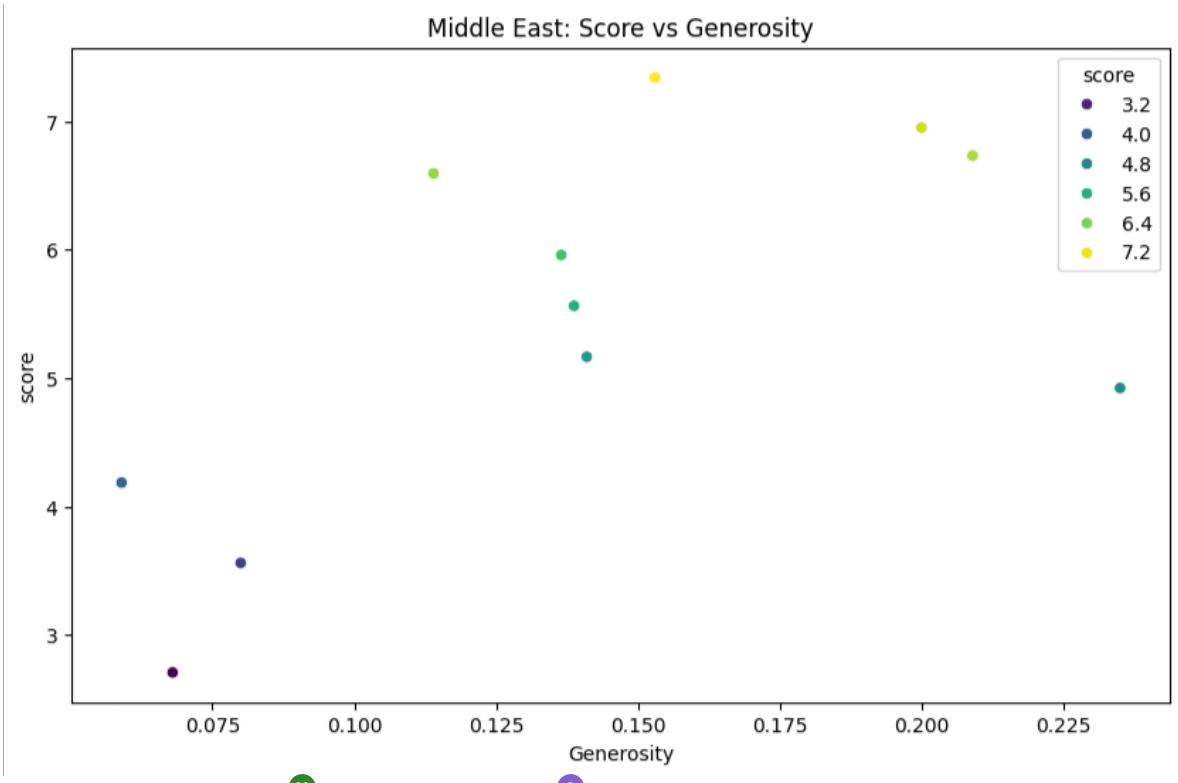


Fig 5.5: Scatter plot for Middle East between Happiness score and Generosity

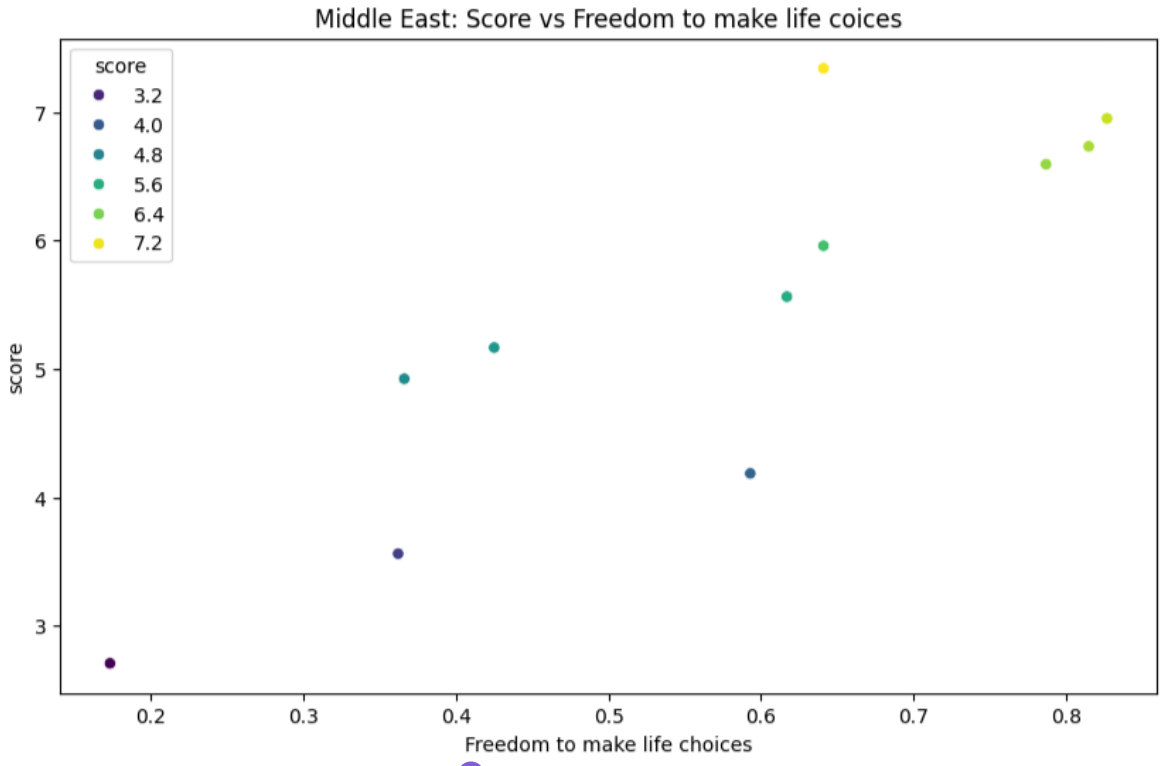


Fig 5.5: Scatter plot for Middle East between Happiness score and the Freedom to make life choices.


Fig 5.6: Heatmap of Middle East for the compared metrics.

---

## 7.1 Identify outlier countries in both regions based on Score and GDP per Capita.

| | Country name | score | Log GDP per capita | Social support | Healthy life expectancy | Freedom to make life choices | Generosity | Perceptions of corruption | Dystopia + residual | Happiness_Category | Composite Score | GDP Score Gap | Region |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | Nepal | 5.158 | 0.965 | 0.990 | 0.443 | 0.653 | 0.209 | 0.115 | 1.783 | Medium | 0.8159 | -4.193 | South |
| 1 | Pakistan | 4.657 | 1.069 | 0.600 | 0.321 | 0.542 | 0.144 | 0.074 | 1.907 | Medium | 0.7039 | -3.588 | South |
| 2 | India | 4.054 | 1.166 | 0.653 | 0.417 | 0.767 | 0.174 | 0.122 | 0.756 | Medium | 0.7874 | -2.888 | South |
| 4 | Afghanistan | 1.721 | 0.628 | 0.000 | 0.242 | 0.000 | 0.091 | 0.088 | 0.672 | Low | 0.3238 | -1.093 | South |

| | Country name | score | Log GDP per capita | Social support | Healthy life expectancy | Freedom to make life choices | Generosity | Perceptions of corruption | Dystopia + residual | Happiness_Category | Region |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 8 | Yemen | 3.561 | 0.671 | 1.281 | 0.293 | 0.362 | 0.080 | 0.113 | 0.760 | Low | Middle Eastern |
| 9 | Lebanon | 2.707 | 1.377 | 0.577 | 0.556 | 0.173 | 0.068 | 0.029 | -0.073 | Low | Middle Eastern |

Fig 5.7: Result of identifying outliers in both the regions.

## 7.2 Plot these outliers and discuss their implications

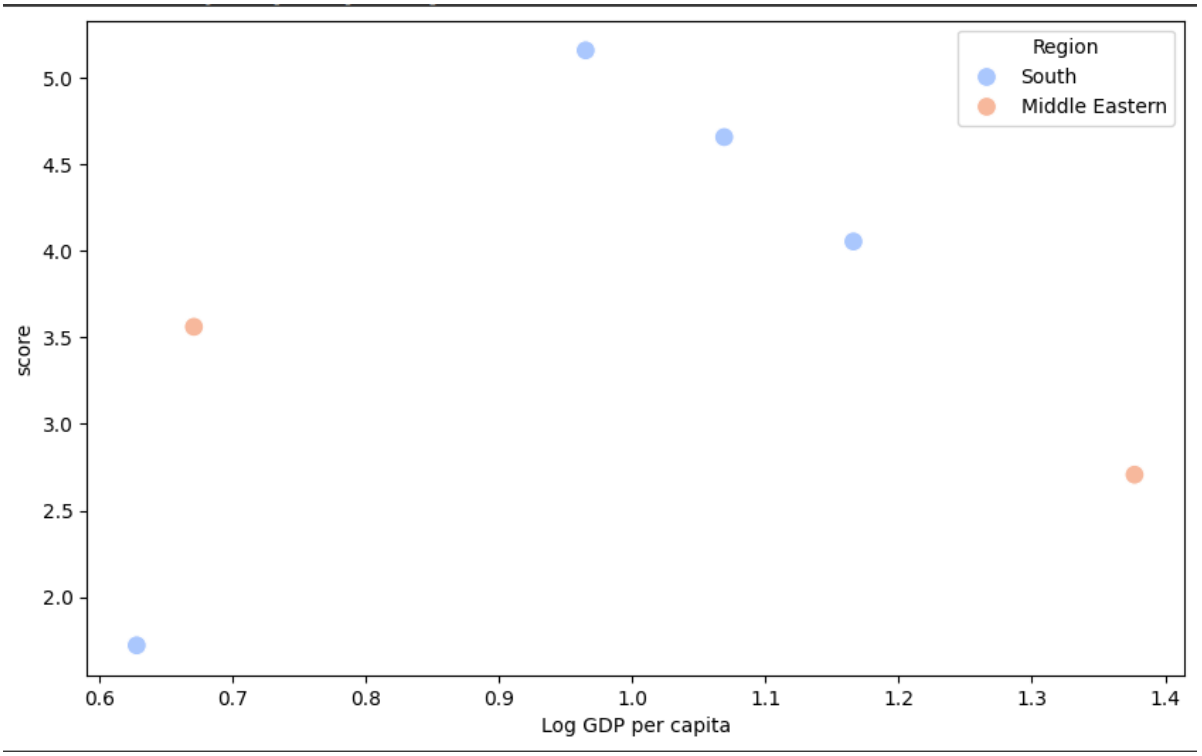


Fig 5.8: Scatter plot of combined outliers of both countries.

These outliers skew the data making these regions appear better / worse in different metrics which can mislead the interpretation of the actual situation in these regions. Especially in the case of South Asia, where 3 out of 8 countries are outliers, which is roughly ~37.5% of the data. These points make the data skewed which can exaggerate or minimize the true trends in the data, they can mess averages and any important decisions made from these data can lead to unwanted results. Thus, outliers, especially when they make up a significant portion of the available data, can significantly impact the overall result of the region's score.

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## 8.1 Create boxplots comparing the distribution of Score between South Asia and the Middle East

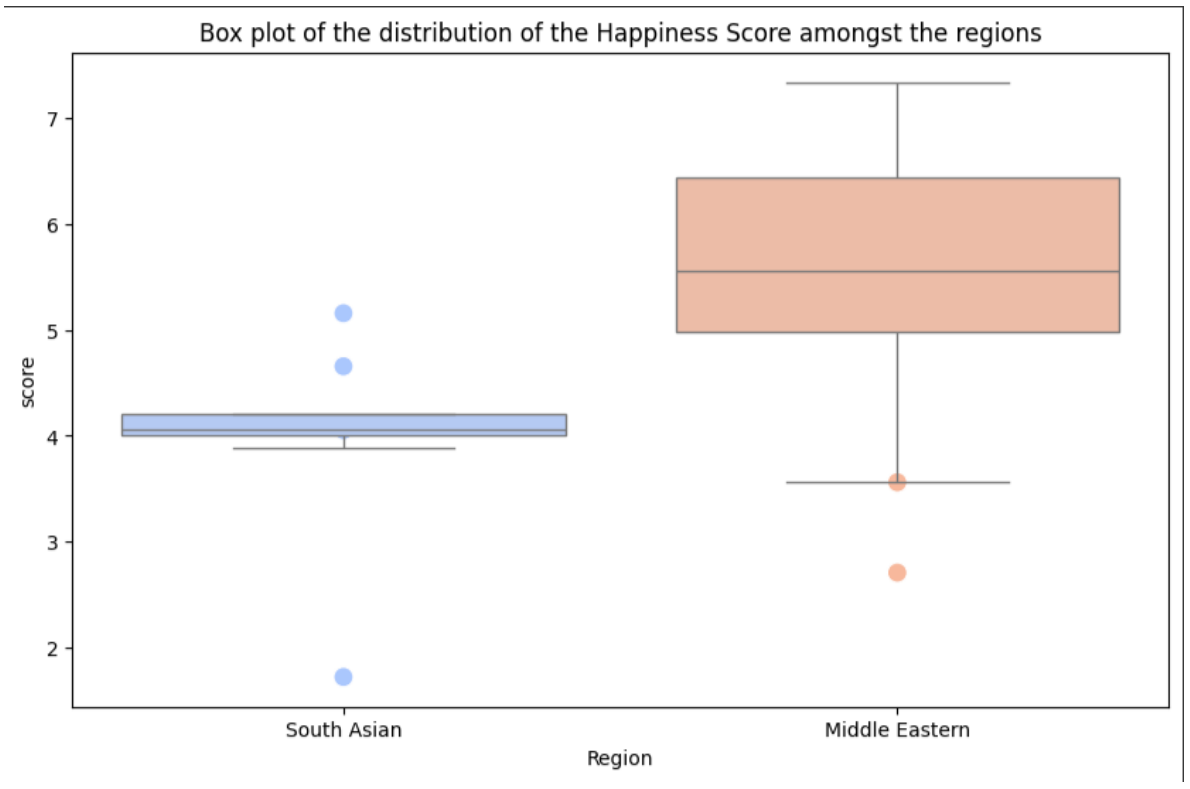


Fig 5.9: Box plot of the distribution of score amongst the regions with outliers.

## 8.2 Interpret the key differences in distribution shapes, medians, and outliers.

The Middle East has more countries, so naturally, their box is bigger. Even though there are more countries, it has fewer outliers. Outliers as we know mess with the overall average and can skew the distribution.

South Asia only has 8 countries, and 3 of them are outliers. Because of this, the size of the box for South Asia is smaller, and the median is closer to the first quartile. The whisker for the third quartile is missing, which means all the data is below Q3. The 3 outliers( two above Q3 and one below Q1) signal that a couple of countries are performing exceptionally well compared to the rest, while one is significantly lower. The countries doing well have a score of ~4.5 to 5.25, which is further than the mean of ~ 4. Whereas the outlier at the bottom, has a score of ~1.75 which is much lower than the average.

For the Middle East, the median is slightly not centered, but the skewness isn't as big as in South Asia. The whisker for Q1 is a bit longer than Q3, meaning the lower end of the data is more spread out. There are two outliers ( one just past the 1.5 * IQR range from Q1 and one further out) . These outliers fall in the ~2.8–3.5 happiness score range, much lower than the average of ~5.5 .

# Conclusion:

In conclusion, we have noticed that metrics such as GDP, healthy life expectancy , social support, generosity, freedom to make life choices and perception of corruption influence the happiness scores. We used the world health report to analyse these metrics and discover outliers and compare these metrics between these regions.

The findings from these exercises reveal a significant difference between South Asia and the Middle East. The Middle East has greater happiness and scores better than South Asia in all the metrics that were compared. Furthermore, South Asia shows a greater variability of happiness with countries like Nepal and India performing significantly better than expected , while other countries like Afghanistan are performing exceptionally low. Furthermore, the presence of outliers especially in South Asia has skewed the regional averages making the data possibly less representative of the actual situation in the region.

Overall, this analysis offers a view of the happiness scores along with other metrics, helping to highlight the differences between these regions and exploring complicated relationships amongst the metrics.

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