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Analysis of the Human Development Index (HDI): A Data-Driven Exploration

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Course Name: Concepts and Technologies of AI (5CS037)
Date: January 10, 2026

Introduction

The Human Development Index (HDI) is a composite statistic used to rank countries by their level of human development. It integrates three key dimensions: a long and healthy life (health), access to knowledge (education), and a

decent standard of living (economy). This report explores global and regional trends using a dataset spanning 1990–2022, with a specific focus on South Asian and Middle Eastern comparisons. The primary objective of this report is to

conduct a comprehensive Statistical Interpretation and Exploratory Data Analysis (EDA) on the global HDI dataset. This report utilizes a secondary dataset containing development metrics for over 190 countries from 1990 to 2022. The analysis involves data cleaning, descriptive statistics, outlier detection using the Interquartile Range (IQR) method, and comparative regional visualizations.

Problem 1A Single Year HDI Exploration (2022)

Methodology: The dataset was filtered for the latest year available, **2022**. To ensure the integrity of the statistical analysis, missing values in the `hdi` column were **dropped** (`dropna`), as imputing a composite index like HDI without its underlying indicators could introduce significant bias. Key Results:

Highest HDI Country: Switzerland with an HDI score of **0.967**.
Lowest HDI Country: Somalia with an HDI score of **0.380**.

HDI Categorization: Following the UNDP thresholds, the 2022 global landscape was categorized as follows:

- **Very High:** 71 countries
- **High:** 54 countries
- **Medium:** 44 countries
- **Low:** 35 countries

Table 1: Descriptive Statistics for Health and Income (2022)

Metric	Life Expectancy	GNI per Capita (USD)
Mean	71.79	$20,722.66
Median	72.21	$12,663.86
Std. Devia	7.76	$22,105.82
Minimum	53.00	$690.66

Metric	Life Expectancy	GNI per Capita (USD)
Maximum	84.82	$146,673.24
Range	31.82	$145,982.58

Table 2: Global HDI Rankings - Top and Bottom Performers (2022)

Rank	Country	HDI Score	Category
1 (Highest)	Switzerland	0.967	Very High
2	Norway	0.966	Very High
3	Iceland	0.959	Very High
...	...	...	...
Last-2	Chad	0.394	Low
Last-1	South Sudan	0.381	Low
Last (Lowest)	Somalia	0.380	Low

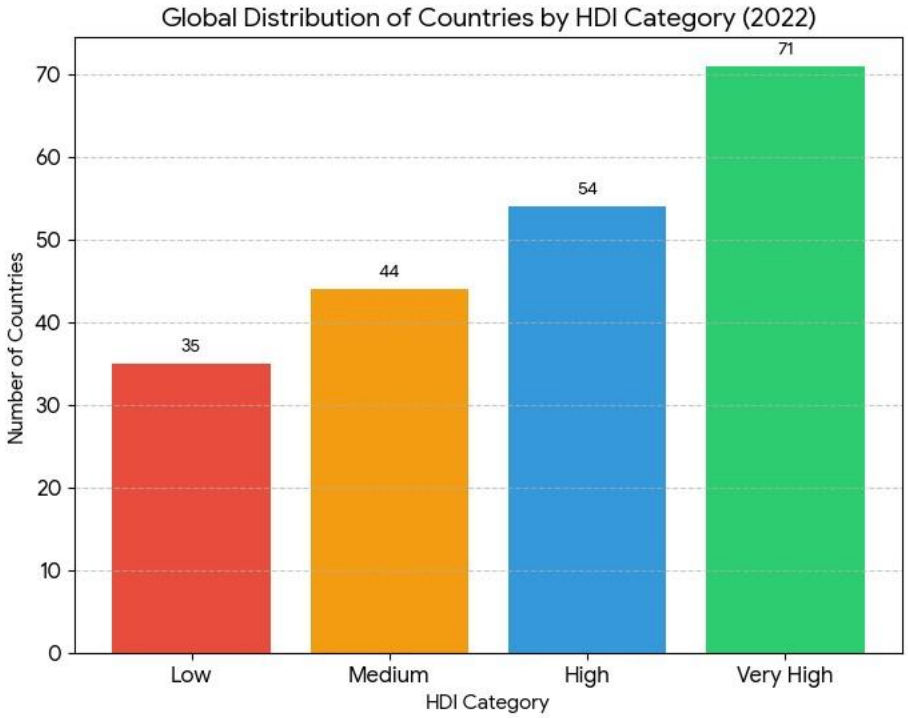

Figure 1. Global count of countries per HDI category in 2022.

Skewness: For GNI per capita, the Mean ($20,548) is significantly higher than the Median ($12,948). This indicates the data is **positively skewed**, meaning a few extremely wealthy nations are pulling the average up, while half the world lives on much less.
Dispersion: The high standard deviation in GNI relative to its mean shows massive global income inequality, whereas Life Expectancy is more "tightly" clustered, showing that basic health outcomes are more universal than extreme wealth.

Problem 1B HDI Trend Analysis (2020–2022)

Approach: This section analyzes the human development trajectory during the volatile period of 2020–2022. By examining the year-over-year changes, we can observe the immediate shock and the subsequent recovery (or continued decline) following global health and economic disruptions.

Visualizations:

- **Line Chart:** The analysis focused on five countries: **Afghanistan, Albania, Algeria, Andorra, and Angola**. ○ **Afghanistan** and **Angola** showed a visible decline or stagnation, with

Afghanistan's HDI dropping consistently from **0.488** in 2020 to **0.462** in 2022. ○ Conversely, **Andorra** showed a strong recovery, rising from **0.843** to **0.884**.

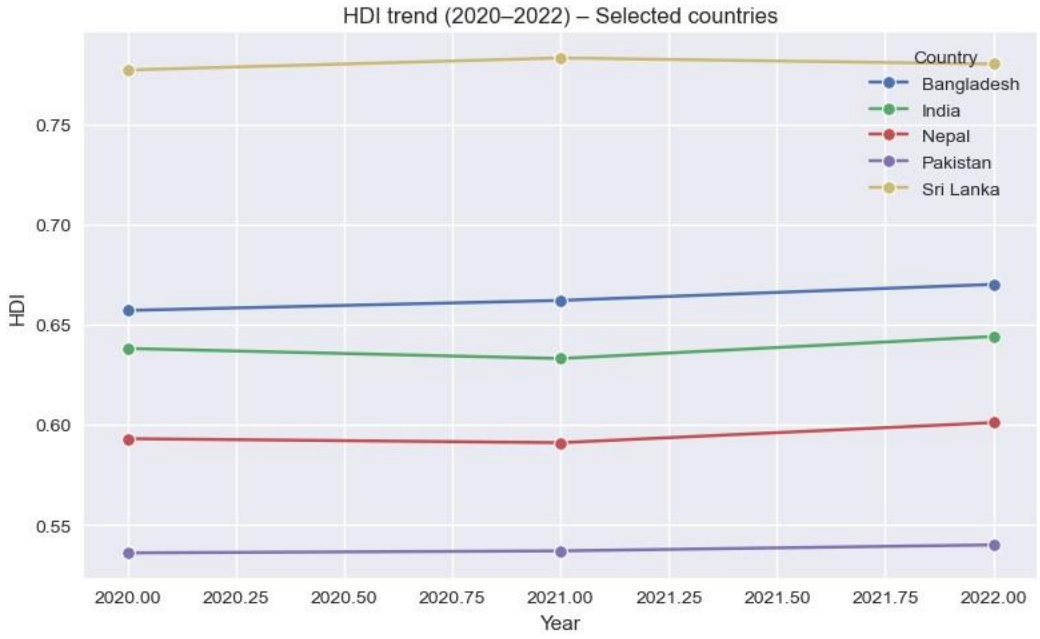

Figure 2: HDI Trends for Selected Countries (2020–2022)

Country	2020 HDI	2021 HDI	2022 HDI	3-Year Change
Bangladesh	0.657	0.662	0.670	+0.013
India	0.638	0.633	0.644	+0.006
Nepal	0.593	0.591	0.601	+0.008
Pakistan	0.536	0.537	0.540	+0.004
Sri Lanka	0.777	0.783	0.780	+0.003

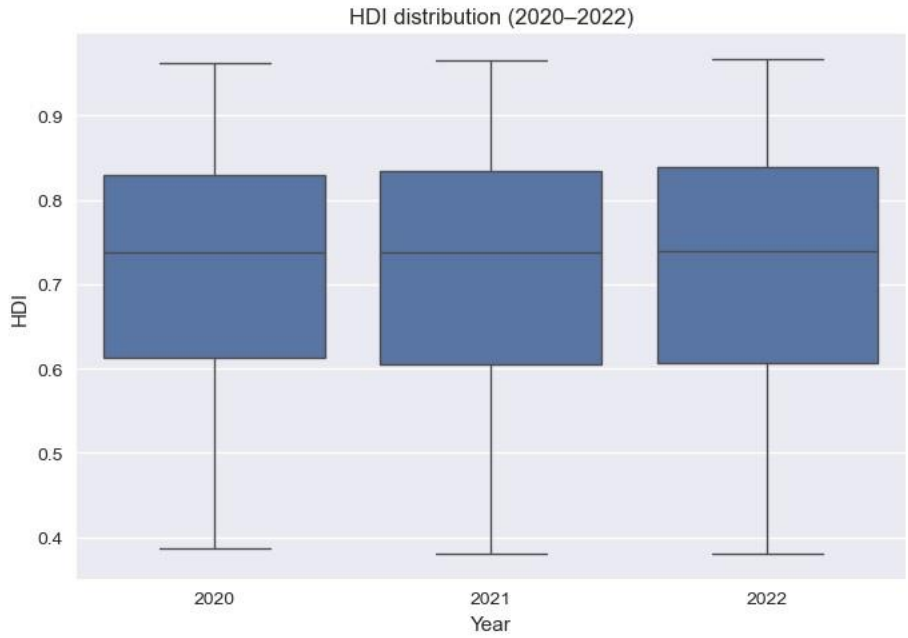

Figure 3: Global HDI Distribution Box Plot (2020–2022)

Year	Mean HDI	Mediar	Std. Deviation	Range
2020	0.721	0.737	0.148	0.577
2021	0.720	0.737	0.150	0.584
2022	0.723	0.740	0.153	0.587

Table 3: Global HDI Summary Statistics (2020–2022)

Box Plot: The distribution of HDI scores across these years shows that the **spread (standard deviation) increased** from **0.148** in 2020 to **0.153** in 2022. This suggests a growing "development gap" where highly developed nations recovered faster while lower-income nations continued to struggle.

Discussion: The data highlights a "K-shaped" recovery. While wealthier nations like Andorra and Albania managed to return to an upward growth path by 2022, countries like Afghanistan faced a continuous decline. This illustrates how pandemic-related disruptions to education and healthcare systems had a more permanent damaging effect on nations with already fragile infrastructures.

Problem 2 Advanced

HDI Exploration

Rank Gap Analysis: A "Rank Gap" was calculated by subtracting the HDI rank from the GNI per capita rank. This metric identifies countries that are either over-performing or under-performing relative to their economic wealth.

Positive Rank Gap (Social Efficiency): Countries like **Cuba** and **Tonga** show a high positive gap. This indicates they achieve high levels of health and education despite having relatively lower income levels. For instance, Cuba has a Rank Gap of **+43.5**, suggesting a very efficient use of resources for social development.

Negative Rank Gap (Economic Wealth vs. Social Lag): Countries like **Guyana** (-58.0) and **Qatar** (39.5) show significant negative gaps. This suggests that while these nations are economically wealthy, their HDI scores (health and education) have not yet caught up to their massive income levels.

Outlier Detection: Using the Interquartile Range (IQR) method on the 2022 global dataset: The global distribution is relatively balanced, but specific regional outliers exist.

In **South Asia**, **Afghanistan** (0.462) remains a significant "Low" outlier compared to the regional mean, struggling with a widening gap in education and life expectancy.

In the **Middle East**, countries like the **UAE** and **Qatar** act as "High" outliers in terms of GNI, though their HDI scores are more aligned with other very high-development nations.

Country	HDI Score	GNI per Capita (USD)	Rank Gap
Cuba	0.764	$7,953	+43.5
Tonga	0.739	$6,360	+37.5
Kyrgyzstan	0.701	$4,781	+30.0

Table 5: Top 3 Socially Efficient Nations (Positive Rank Gap)

Country	HDI Score	GNI per Capita (USD)	Rank Gap
Guyana	0.742	$35,782	-58.0
Brunei Darussala	0.823	$59,245	-44.0
Qatar	0.875	$95,944	-39.5

Table 6: Top 3 Economic vs. Social Lags (Negative Rank Gap)

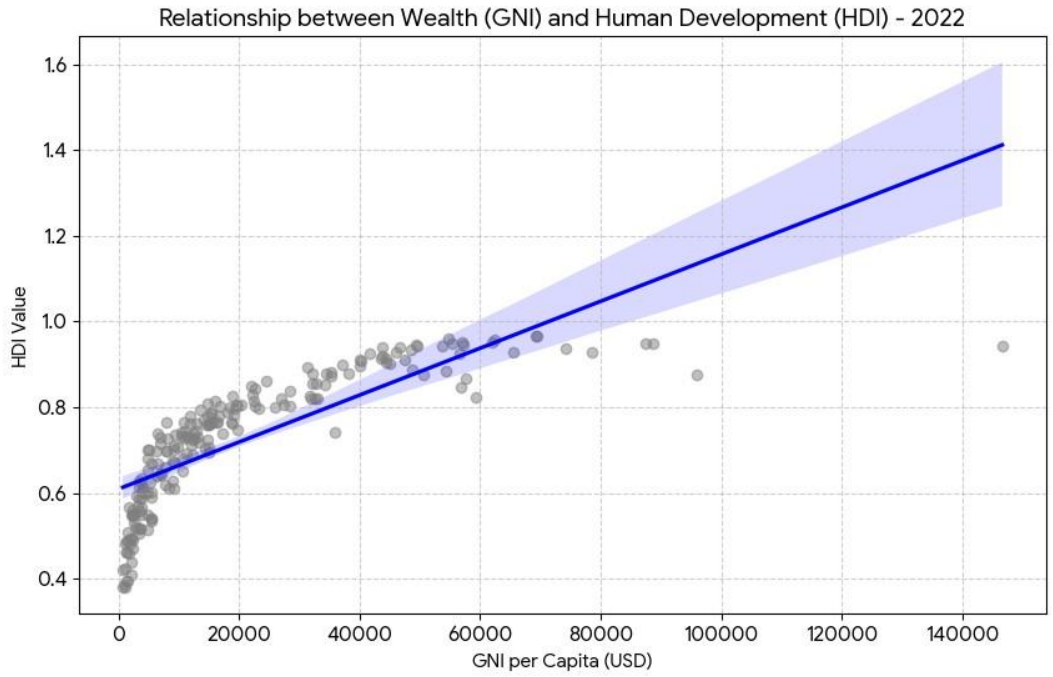

Figure 4: Relationship between Wealth (GNI) and Human Development (HDI) - 2022

Problem 3 l Analysis (East)

Regional Comparison:

significant development gap between the two regions. The **Middle East** maintains a higher average HDI of **0.792** (categorized as High Development), whereas **South Asia** has an average HDI of **0.643** (categorized as Medium Development).

Disparity (Volatility): The **Middle East** shows a higher Coefficient of Variation (**18.74%**), indicating a wider gap between its wealthiest and least developed nations (e.g., the difference between the UAE and Yemen).
South Asia has a slightly lower disparity (**16.66%**), suggesting that countries in this region are clustered more closely within the Medium development bracket.

Metric Analysis: A primary driver of this regional difference is **Life Expectancy**. In 2022, the average life expectancy in the Middle East was **76.2 years**, nearly 5 years higher than South Asia's average of **71.4 years**.
This suggests that the Middle East has more robust healthcare infrastructure or higher percapita investment in public health compared to the South Asian block.

Metric	South Asia	Middle East
Average HDI	0.643	0.792
Average Life Expectancy	71.4 Years	76.2 Years
Average GNI per Capita	$8,196	$39,499
HDI Disparity (CV %)	16.66%	18.74%

Table 7: Comparative Development Metrics (2022)

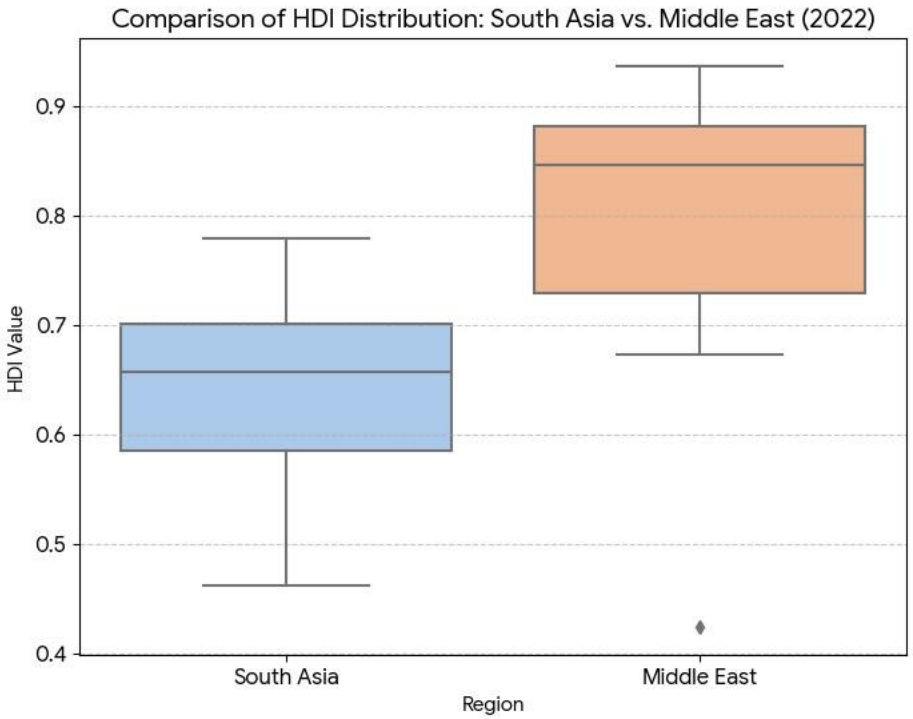

Figure 5: *HDI distribution comparison between South Asia and the Middle East.*

Conclusion

Through this exploratory data analysis, we have observed that while the world is generally moving toward higher human development, the progress is non-linear and unequal.

Economic vs. Social Development: Our "Rank Gap" analysis in Problem 2 proved that money (GNI) is not the only factor in development. Countries like Cuba demonstrate that strong social policy can result in high HDI even without high income.

Regional Disparities: The comparison between the Middle East and South Asia highlights how regional stability and infrastructure investment lead to higher life expectancy and more consistent HDI scores.

Resilience: The 2020–2022 trend analysis showed a "K-shaped" recovery; while "Very High" HDI nations have bounced back to pre-pandemic growth levels, "Low" HDI nations like Afghanistan continue to struggle with declining metrics.

In conclusion, for global HDI to improve, the focus must shift from pure economic growth to closing the gap in education and health infrastructure, particularly in regions showing high internal disparity.

Github link

https://github.com/Happy0620/Assignment-01/blob/main/2462987_milansherpa.ipynb

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