Vision 2050: Forecasting India's Place in the World with AI

- *Saket Manolkar*

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Objective

The core aim of this project is to deploy AI and ML techniques to chart India's journey towards 2050, focusing on 8 critical development metrics such as **GDP, GDP growth, GDP per capita, employment-to-population ratio, unemployment rate, literacy rate, population growth rate, and access to electricity**. The project will involve not just predicting future values but also mapping historical trends for each development metric against global benchmarks to provide a broader contextual backdrop for India's growth narrative.

This project utilizes **World Bank data from 1960 to 2022** to first use K-Means clustering and PCA to **group countries into first, second, and third world categories** using **8 key indicators** (GDP, GDP growth, GDP per capita, employment-to-population ratio, unemployment rate, literacy rate, population growth rate, and access to electricity) and **visualize India's position in the world in 2022**. Post clustering, we **visualize India's developmental trajectory** against global trends. Next, we **forecast the values of these indicators in the year 2050** using Linear Regression and ARIMA models. The forecasted data then undergoes **a second round of grouping to visualize India's global standings in 2050**, offering insights into the dynamics of development and India's prospective position on the world stage. **This two-pronged clustering approach—initial and predictive—forms the crux of our analytical framework.**

For those interested in the methodologies and data behind these visualizations and predictions, the project's GitHub repository houses all relevant datasets and scripts.

GitHub Repository : https://github.com/saketmanolkar/Vision-2050

Methodology

a) Data Collection:

A mass extensive historical data from the World Bank for the period of 1960-2022, establishing a solid database for analysis.

b) Unsupervised Learning with K-means Clustering and PCA:

- Apply PCA for dimensionality reduction to distill the most influential features, optimizing the dataset for clustering.

- Conduct K-means clustering to categorize countries into 3 groups (1st world countries, 2nd world countries, 3rd world countries) based on historical development indicators, identifying India's standing amongst global peers in the year 2022.

c) Historical Data Visualization:

- Graph the historical trajectories of India's chosen indicators to illustrate the country's developmental progress over time.
- Compare these trajectories to global trends, capturing India's relative progress on a comprehensive dashboard.

d) Predictive Modeling with ARIMA and Linear Regression:

Implement Linear Regression**,** ARIMA models to forecast the 2050 values of each development indicator for India, based on historical data patterns.

e) Prediction & Integration of Predicted Data into Clustering post Prediction

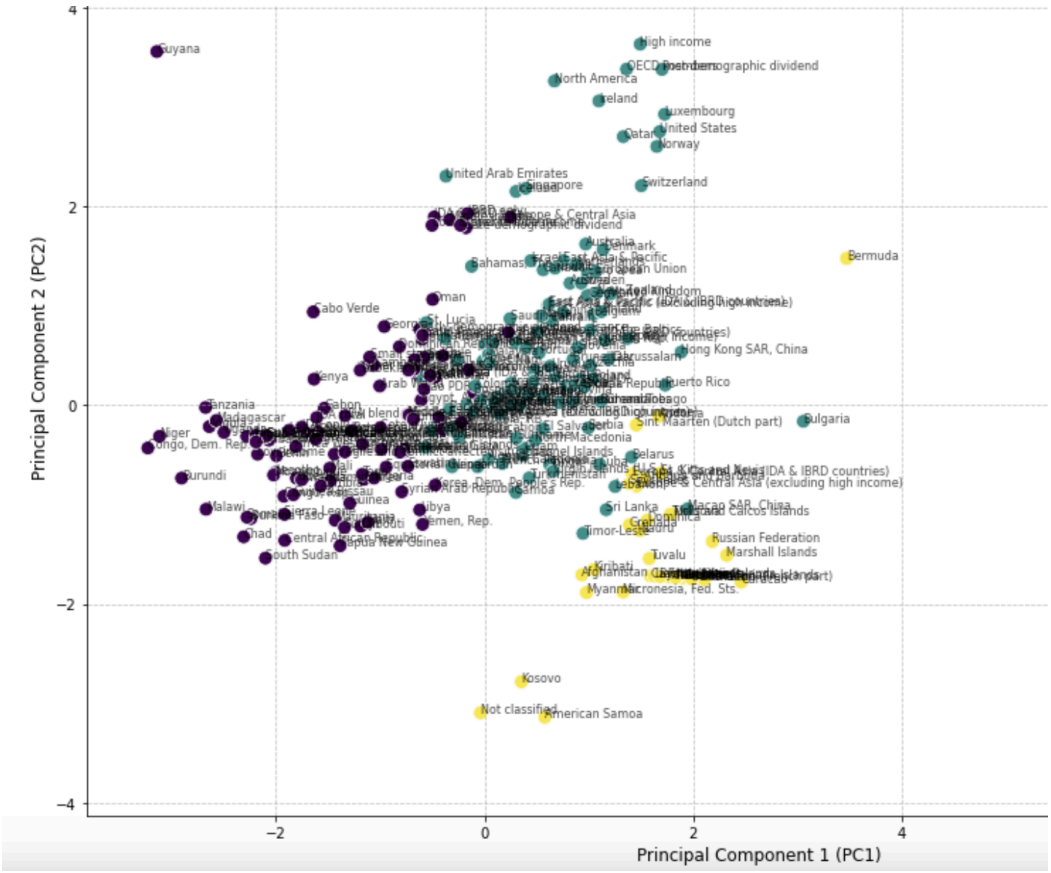
- Upon forecasting the 2050 indicator values, reintegrate these data points into the PCA-transformed dataset.
- Re-run the K-means algorithm to determine the cluster into which India is likely to fall in 2050, based on its forecasted development indicators.

f) Outcome Assessment:

- Synthesize the historical trend analysis with predictive modeling outcomes to articulate a comprehensive narrative of India's potential development status by 2050.
- Assess India's projected cluster classification in relation to current global economic and development standings.

Pre-Forecast Clustering

1) Clusters formed in 2022 dataset using K-Means and PCA



** While Cluster 1 is designated as "First World Countries", Cluster 0 as “Third World Countries” and Cluster 2 as “Second World Countries”, this classification is anchored in the selected parameters. In reality, the true essence of "First World" involves socio-economic, political, and cultural considerations that extend beyond our current clustering criteria.

** A notable point to emphasize is that, while all countries traditionally deemed as "First World" find themselves in Cluster 1, not every country in Cluster 1 aligns precisely with this classification.

India is found in “Cluster 0 “

2) Formed Clusters

Cluster 0:

Africa Eastern and Southern, Africa Western and Central, Albania, Angola, Arab World, Benin, Bhutan, Bosnia and Herzegovina, Botswana, Brazil, Burkina Faso, Burundi, Cabo Verde, Cambodia, Cameroon, Central African Republic, Central Europe and the Baltics, Chad, Chile, Comoros, Congo, Dem. Rep., Congo, Rep., Cote d'Ivoire, Djibouti, Dominican Republic, Early-demographic dividend, Ecuador, Egypt, Arab Rep., Equatorial Guinea, Eritrea, Eswatini, Ethiopia, Europe & Central Asia, Fragile and conflict affected situations, Gabon, Gambia, The, Georgia, Guatemala, Guinea, Guinea-Bissau, Guyana, Haiti, Heavily indebted poor countries (HIPC), IBRD only, IDA & IBRD total, IDA blend, IDA only, IDA total, **India**, Iran, Islamic Rep., Kenya, Korea, Dem. People's Rep., Lao PDR, Late-demographic dividend, Latin America & Caribbean, Latin America & Caribbean (excluding high income), Latin America & the Caribbean (IDA & IBRD countries), Least developed countries: UN classification, Lesotho, Liberia, Libya, Low & middle income, Low income, Lower middle income, Madagascar, Malawi, Mali, Mauritania, Middle East & North Africa, Middle East & North Africa (IDA & IBRD countries), Middle East & North Africa (excluding high income), Middle income, Morocco, Mozambique, Namibia, Niger, Nigeria, Oman, Other small states, Papua New Guinea, Pre-demographic dividend, Rwanda, Sao Tome and Principe, Senegal, Sierra Leone, Small states, Somalia, South Africa, South Asia, South Asia (IDA & IBRD), South Sudan, Sub-Saharan Africa, Sub-Saharan Africa (IDA & IBRD countries), Sub-Saharan Africa (excluding high income), Sudan, Syrian Arab Republic, Tanzania, Togo, Tunisia, Uganda, Upper middle income, Uzbekistan, Vanuatu, Venezuela, RB, West Bank and Gaza, World, Yemen, Rep., Zambia, Zimbabwe

Cluster 1:

Algeria, Argentina, Armenia, Australia, Austria, Azerbaijan, Bahamas, The, Bahrain, Bangladesh, Barbados, Belarus, Belgium, Belize, Bolivia, Brunei Darussalam, Bulgaria, Canada, Caribbean small states, Channel Islands, China, Colombia, Costa Rica, Croatia, Cuba, Cyprus, Czechia, Denmark, East Asia & Pacific, East Asia & Pacific (IDA & IBRD countries), East Asia & Pacific (excluding high income), El Salvador, Estonia, Euro area, European Union, Fiji, Finland, France, French Polynesia, Germany, Ghana, Greece, Guam, High income, Honduras, Hong Kong SAR, China, Hungary, Iceland, Indonesia, Iraq, Ireland, Israel, Italy, Jamaica, Japan, Jordan, Kazakhstan, Korea, Rep., Kuwait, Kyrgyz Republic, Latvia, Lebanon, Lithuania, Luxembourg, Macao SAR, China, Malaysia, Maldives, Malta, Mauritius, Mexico, Mongolia, Montenegro, Nepal, Netherlands, New Caledonia, New Zealand, Nicaragua, North America, North

Macedonia, Norway, OECD members, Pacific island small states, Pakistan, Panama, Paraguay, Peru, Philippines, Poland, Portugal, Post-demographic dividend, Puerto Rico, Qatar, Romania, Samoa, Saudi Arabia, Serbia, Singapore, Slovak Republic, Slovenia, Solomon Islands, Spain, Sri Lanka, St. Lucia, St. Vincent and the Grenadines, Suriname, Sweden, Switzerland, Tajikistan, Thailand, Timor-Leste, Tonga, Trinidad and Tobago, Turkiye, Turkmenistan, United Arab Emirates, United Kingdom, United States, Uruguay, Viet Nam, Virgin Islands (U.S.)

Cluster 2:

Afghanistan, American Samoa, Andorra, Antigua and Barbuda, Aruba, Bermuda, British Virgin Islands, Cayman Islands, Curacao, Dominica, Europe & Central Asia (IDA & IBRD countries), Europe & Central Asia (excluding high income), Faroe Islands, Gibraltar, Greenland, Grenada, Isle of Man, Kiribati, Kosovo, Liechtenstein, Marshall Islands, Micronesia, Fed. Sts., Moldova, Monaco, Myanmar, Nauru, Northern Mariana Islands, Not classified, Palau, Russian Federation, San Marino, Seychelles, Sint Maarten (Dutch part), St. Kitts and Nevis, St. Martin (French part), Turks and Caicos Islands, Tuvalu, Ukraine

3) Enhancing the Real-World Relevance of Clustering Analysis

As we delve into the clustering analysis results, it's imperative to recognize the nuances and limitations of our current approach. The clusters defined as "Second World " (cluster 2), "First World" (cluster 1) and "Third World" (cluster 0) are constructed based on a selection of parameters including 'GDP,' 'GDP Growth,' 'GDP Per Capita,' 'Employment to Population Ratio,' 'Unemployment Rate,' 'Literacy Rate,' 'Population Growth,' and 'Access to Electricity.' While these indicators offer valuable insights, it's crucial to acknowledge that this classification might not comprehensively represent the real-world situation.

1. **Limited Parameter Consideration**: The primary limitation lies in the relatively narrow scope of parameters considered for clustering. To present a more holistic view of a country's development, we should expand our parameter set to include:

a) Health Indicators: Life expectancy, healthcare access, disease prevalence.

b) Education Metrics: Educational attainment, quality of education, research and development.

c) Environmental Factors: Sustainability practices, carbon emissions, natural resource management.

d) Social Well-being: Income inequality, social infrastructure, gender equality.

However, due to time constraints, these were not included in the current analysis.

2. **Holistic View of Development**: Development is a multifaceted concept encompassing economic, social, and environmental dimensions. While Cluster 1 is designated as "First World," this classification is anchored in the selected parameters. In reality, the true essence of "First World" involves socio-economic, political, and cultural considerations that extend beyond our current clustering criteria.

3. **Consideration of Cluster 1**: A notable point to emphasize is that, **while all countries traditionally deemed as "First World" find themselves in Cluster 1, not every country in Cluster 1 aligns precisely with this classification**. The clustering is predominantly driven by specific indicators, necessitating a more nuanced examination to accurately portray each country's unique development profile.

4. **Future Analysis Recommendations**: Recognizing the constraints of time and computational resources, it's acknowledged that the inclusion of more parameters might be challenging. However, for future analyses seeking a more realistic representation:

a) Incorporate a Diverse Set of Indicators: Including parameters from various aspects of development.

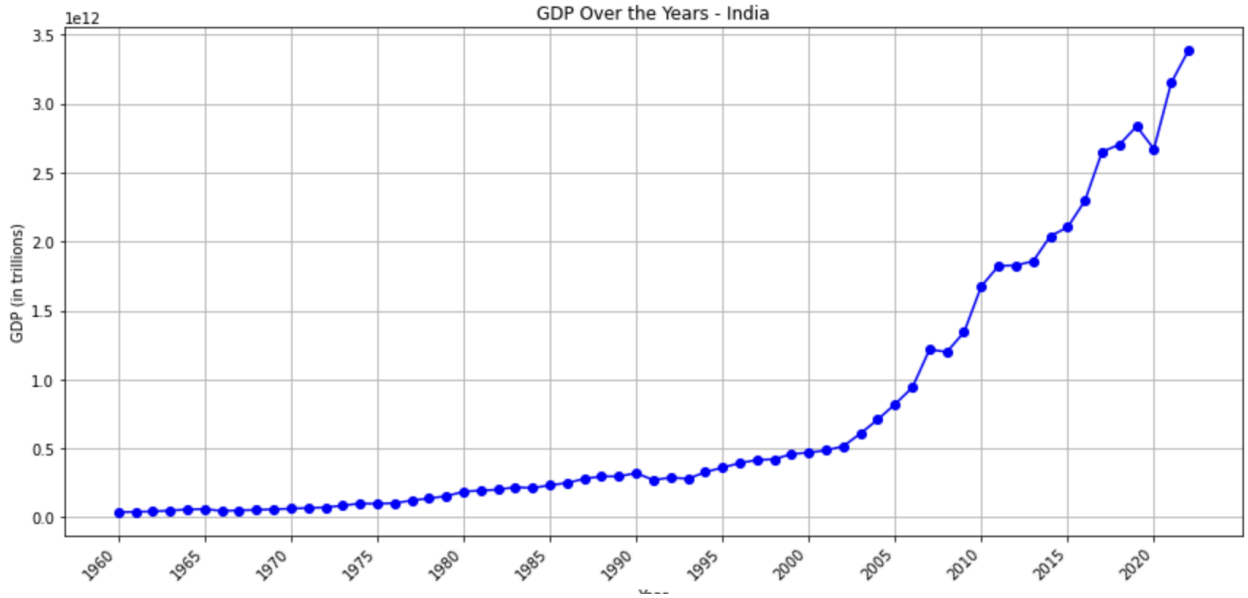
b) Utilize Advanced Analytical Techniques: Explore advanced methods to capture intricate relationships between parameters.

c) Consider Dynamic Factors: Account for dynamic elements influencing development trends over time.

Conclusion: In conclusion, while our current clustering provides valuable insights, the results are contingent on the selected parameters. **By expanding our parameter set in future analyses, we can refine our clustering approach to mirror the complexities of the real-world development landscape more accurately. The consideration of a broader spectrum of factors will undoubtedly contribute to a more nuanced and realistic classification of countries**.

GDP - Visualization and Prediction

1) GDP Over the Years - India



This graph represents India's GDP growth over a period spanning from the 1960s to 2022. Here's a brief analysis:

Initial Period (1960s to late 1980s): During this period, India's GDP shows very gradual growth. This aligns with India's historical economic policies of protectionism, with a focus on self-reliance and import substitution industrialization under a predominantly socialist-oriented approach.

Economic Liberalization (Post-1991): There's a noticeable inflection point in the early 1990s, which likely corresponds to India's economic liberalization policies that began in 1991. These policies included deregulation, reduction of trade barriers, and greater foreign investment, which appear to have spurred increased economic growth.

Rapid Growth (2000s onwards): The steep increase in the GDP trajectory from the early 2000s suggests a period of rapid economic expansion. This could be attributed to further economic reforms, growth in the services sector, particularly IT and ITES (Information Technology Enabled Services), and a demographic dividend of a young and growing workforce.

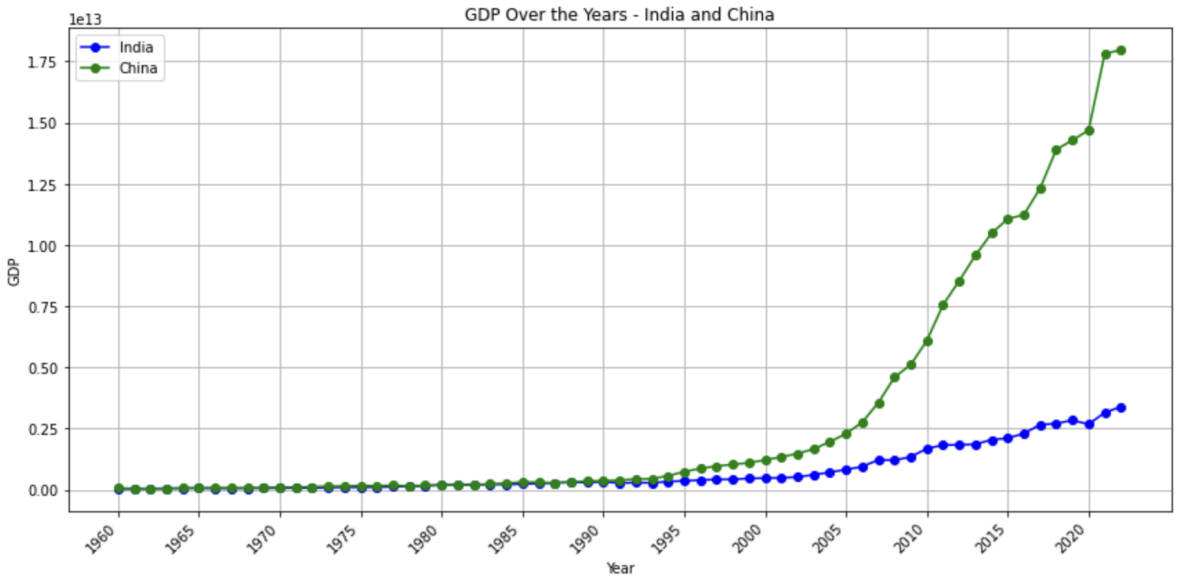
Recent Trends (2010s to 2022): While the graph continues to show an upward trend, there are visible fluctuations in the later years, which may indicate economic volatility or the impact of external factors such as global market dynamics, financial crises, or policy changes. The significant increase in GDP during this time suggests that the Indian economy has become more integrated with the global economy, benefiting from globalization, increased exports, and higher foreign direct investment inflows.

Very Recent Years: There's a noticeable dip right before 2020, which could possibly correspond to the global economic slowdown due to the COVID-19 pandemic. However, the graph ends on a rebound, indicating a recovery phase.

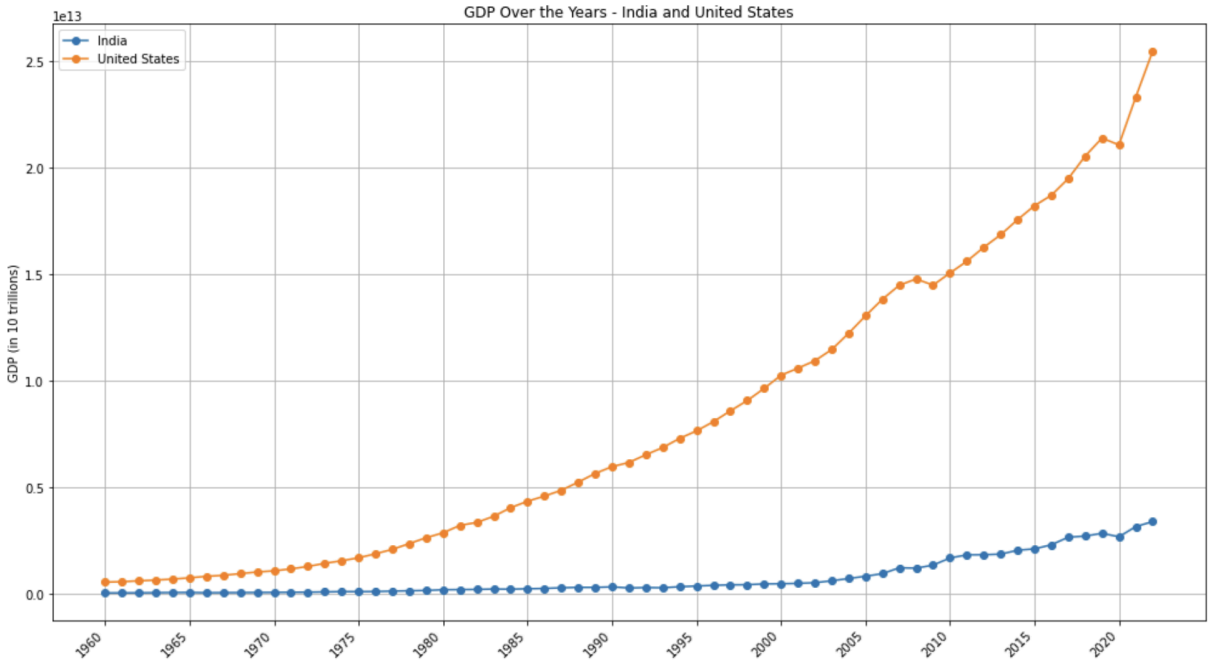
Overall, this graph illustrates India's transition from a slow-growing economy to one of the fastest-growing in the world, marked by significant economic reforms and integration into the global market.

2) GDP Over the Years - India and Pakistan

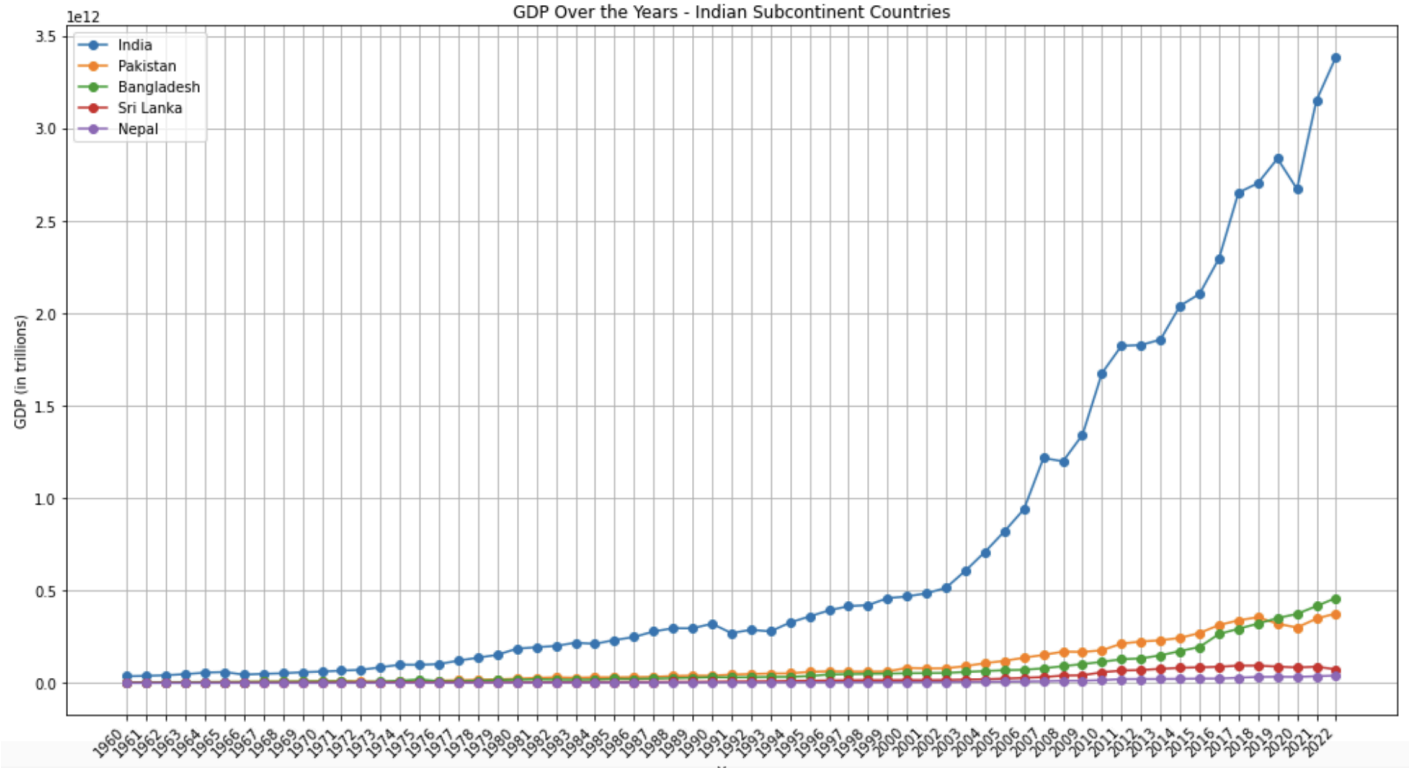
3) GDP Over the Years - India and China



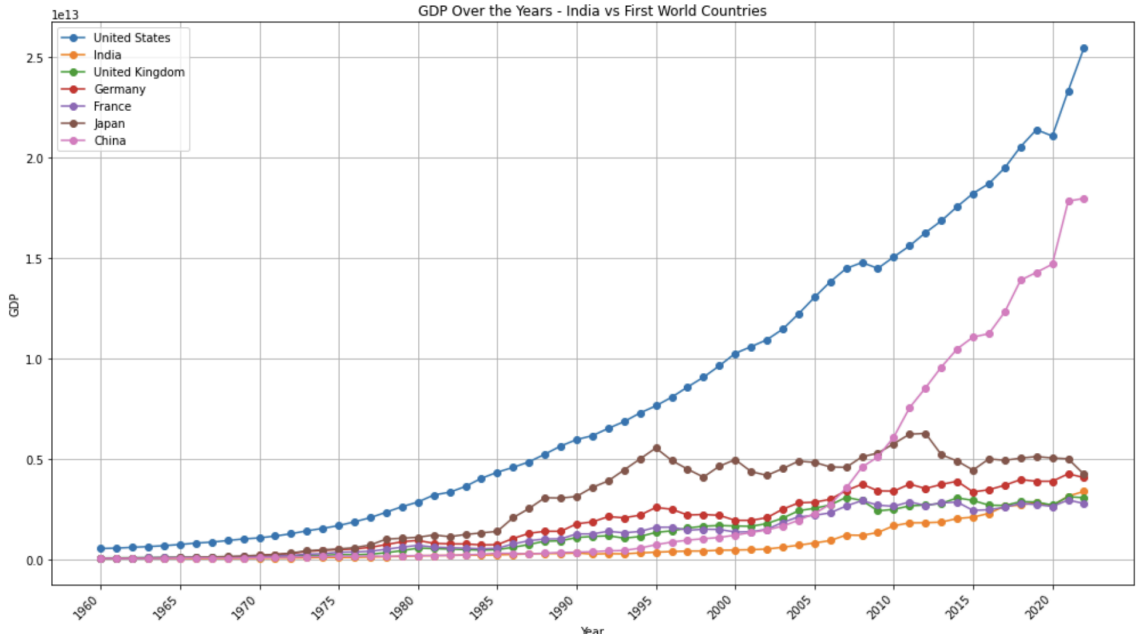
4) GDP Over the Years - India and United States



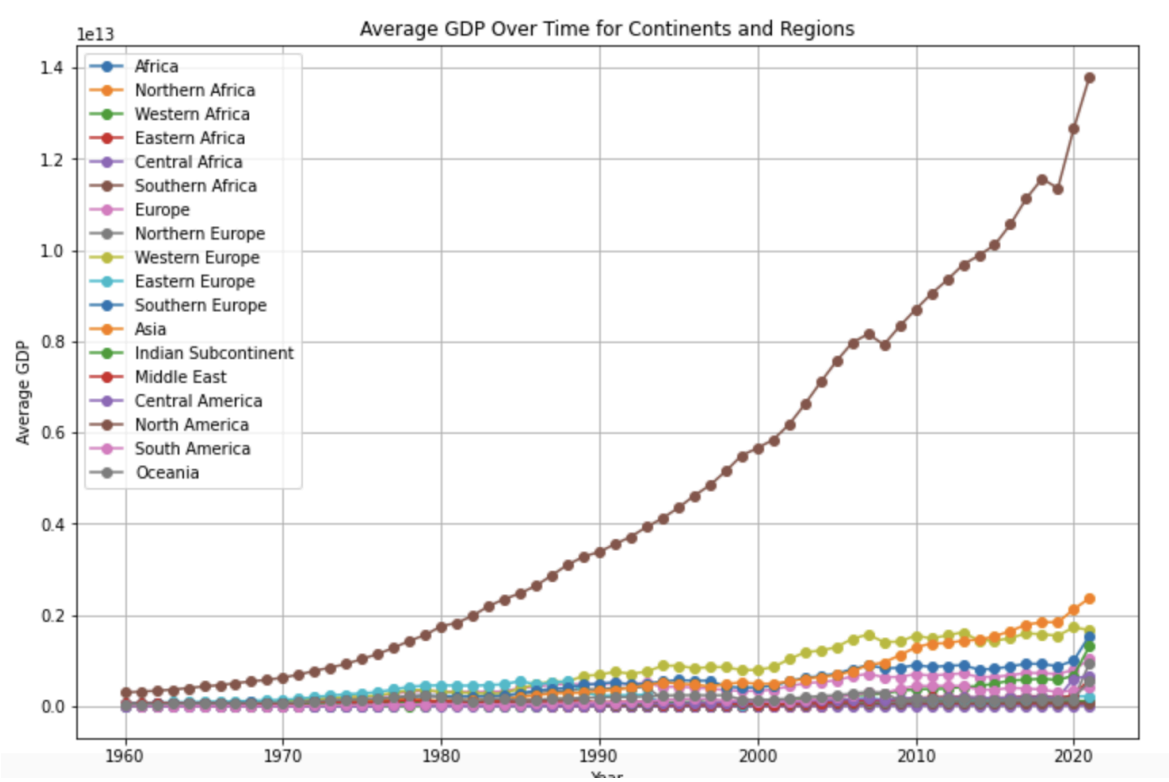
5) GDP Over the Years - Indian Subcontinent Countries



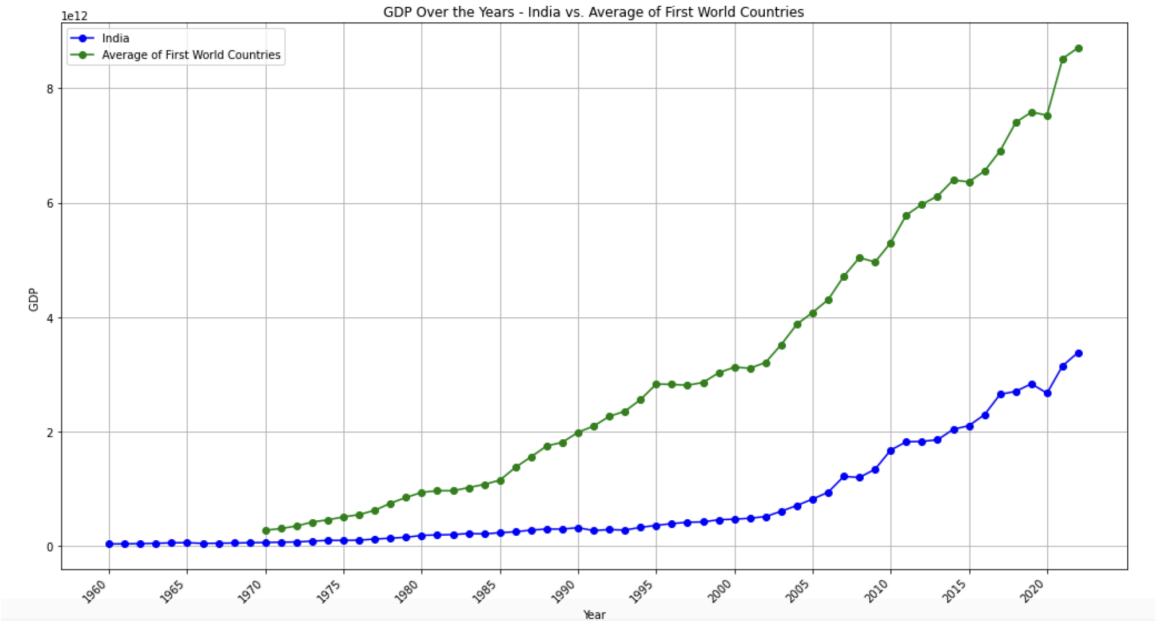
6) GDP Over the Years - India vs First World Countries



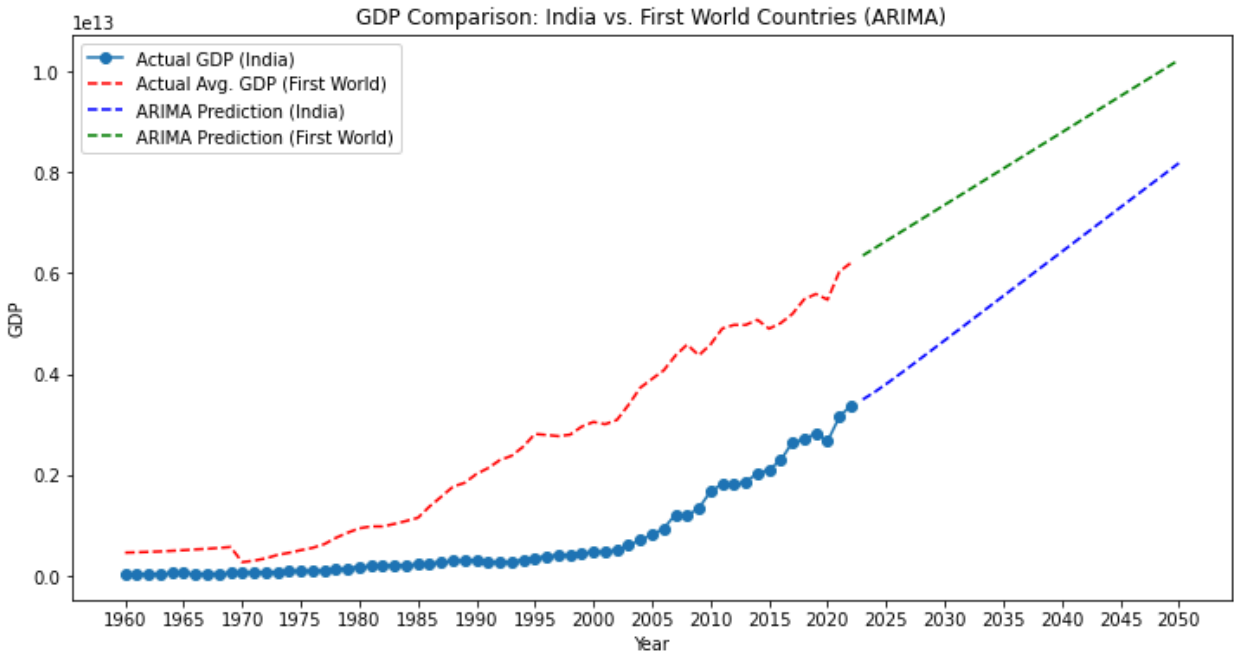
7) Average GDP Over Time for Continents and Regions



8) GDP Over the Years - India vs. Average of First World Countries



9) **GDP Prediction** and Actual GDP Over the Years - India vs. Average of First World Countries

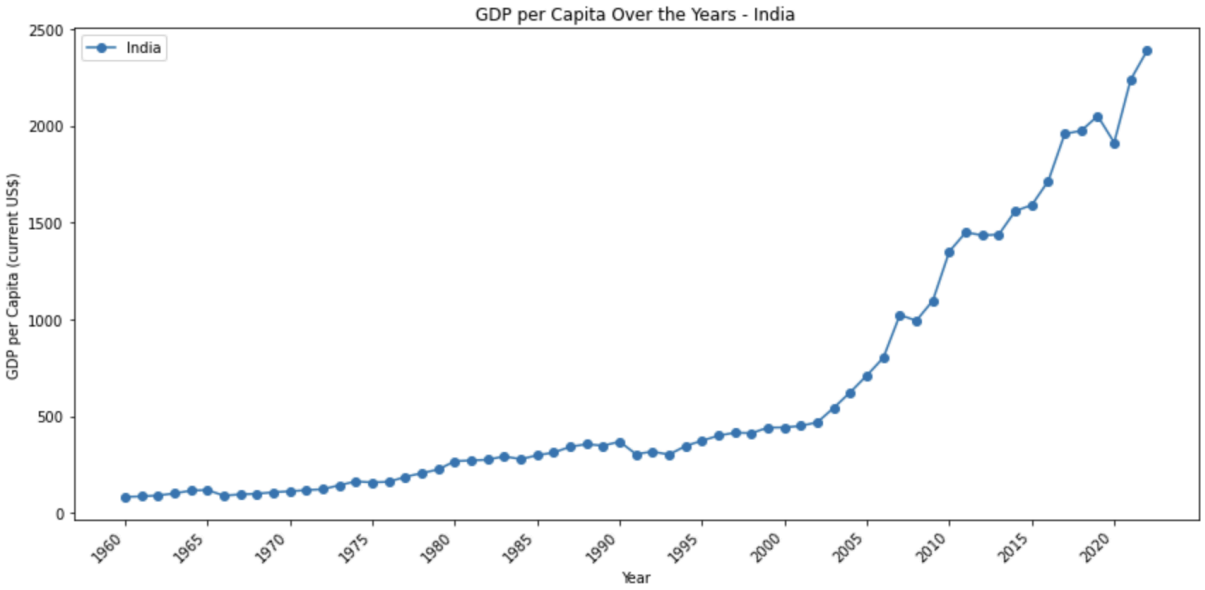


Predicted GDP for India (2023 to 2050):

[3.49604928e+12 3.64125271e+12 3.80255923e+12 3.97143817e+12
 4.14387798e+12 4.31799229e+12 4.49289402e+12 4.66816603e+12
 4.84361217e+12 5.01914018e+12 5.19470670e+12 5.37029132e+12
 5.54588446e+12 5.72148161e+12 5.89708063e+12 6.07268054e+12
 6.24828087e+12 6.42388139e+12 6.59948201e+12 6.77508267e+12
 6.95068335e+12 7.12628403e+12 7.30188473e+12 7.47748542e+12
 7.65308612e+12 7.82868681e+12 8.00428751e+12 8.17988821e+12]

GDP per Capita - Visualization and Prediction

1) GDP per Capita Over the Years - India



The graph depicting India's GDP per capita from the 1960s to 2022 tells a compelling story of economic evolution.

1960s-1970s: Economic Stagnation - During this period, India's GDP per capita shows little to no growth. Initially, the slow growth mirrors India's post-independence focus on agrarian economics and state-led industrialization.

1980s: Gradual Increase - There is a slight uptick in GDP per capita, indicating the beginning of economic reforms. India started initiatives to open up its economy, though progress was slow.

1990s: Economic Liberalization - A noticeable increase in growth rate post early 1990s correlates with major economic reforms. The 1991 economic liberalization marks a turning point, with a gradual ascent into the 2000s. Policies included deregulation, privatization, and opening up to foreign investment.

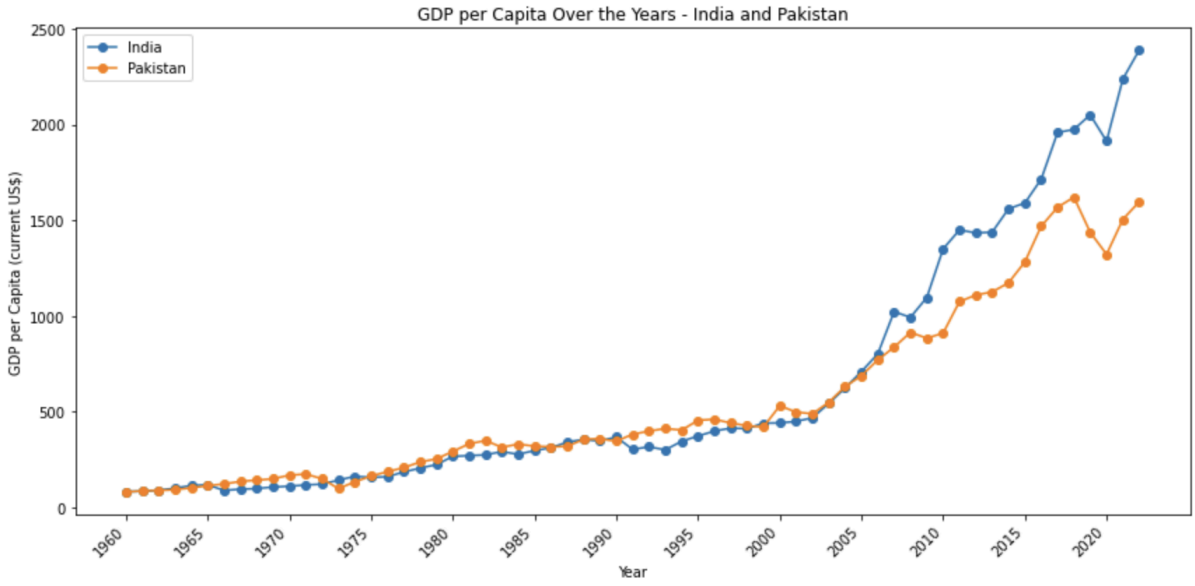
2000s: Steep Growth - The GDP per capita rises sharply, reflecting a period of robust economic expansion.This growth could be due to advances in technology, increased exports, and more foreign direct investment

2010s: Fluctuations Amidst Growth - While the overall trend of growth continues, there are noticeable fluctuations. These could reflect the impact of global financial crises and market volatility.

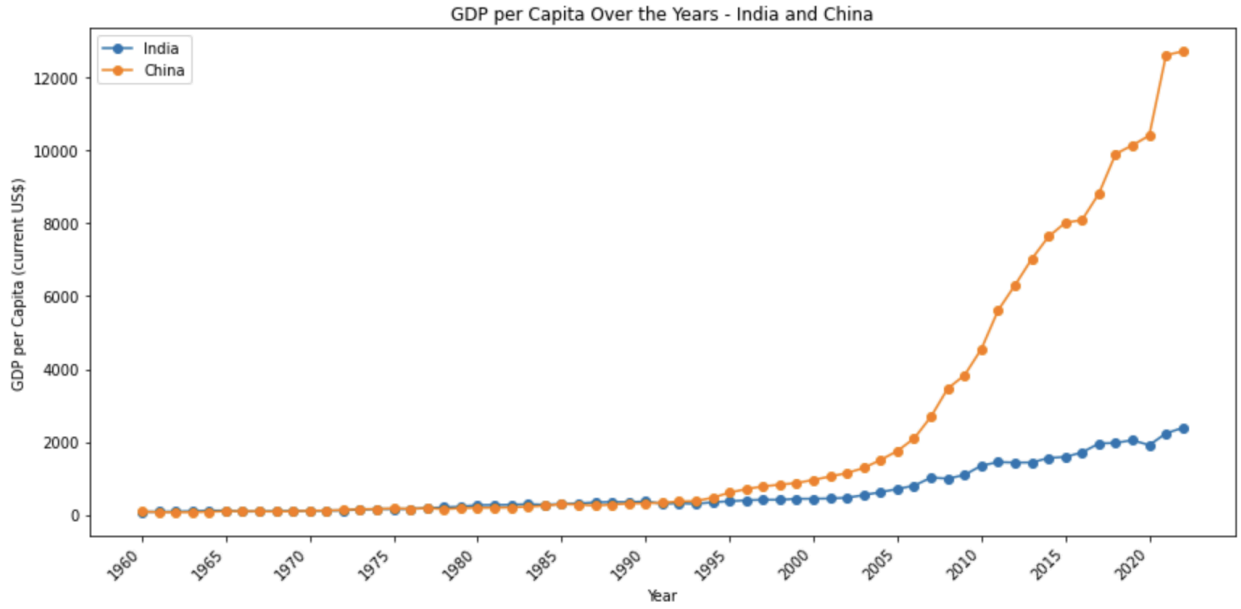
2020s: Continued Ascent with Dips - The graph shows a continued upward trajectory with some dips, possibly due to recent global events like the COVID-19 pandemic. Despite these dips, the long-term trend indicates a growing economy

In the broader context, this graph serves as a testament to India's journey from a primarily agrarian society to a burgeoning hub of technology and manufacturing. It encapsulates the challenges and triumphs of a nation on the move, striving to balance growth with equity. As India continues to forge its path on the global stage, this upward trend in GDP per capita will be pivotal to watch, for it represents not just economic might but the aspirations of its people for a more prosperous future.

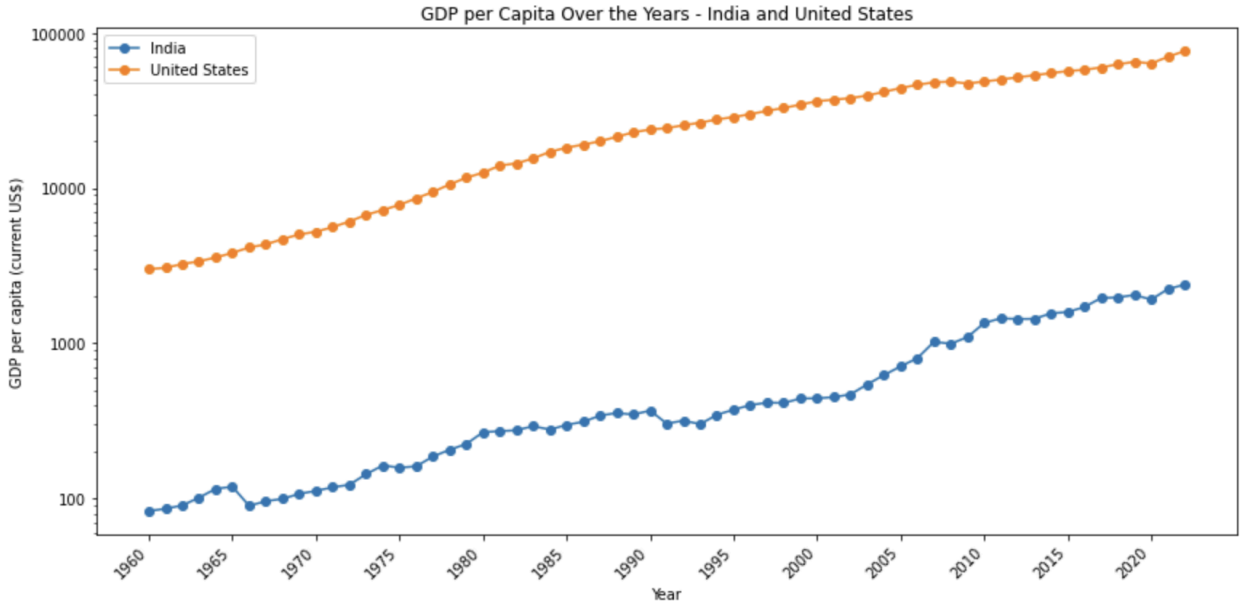
2) GDP per Capita Over the Years - India and Pakistan



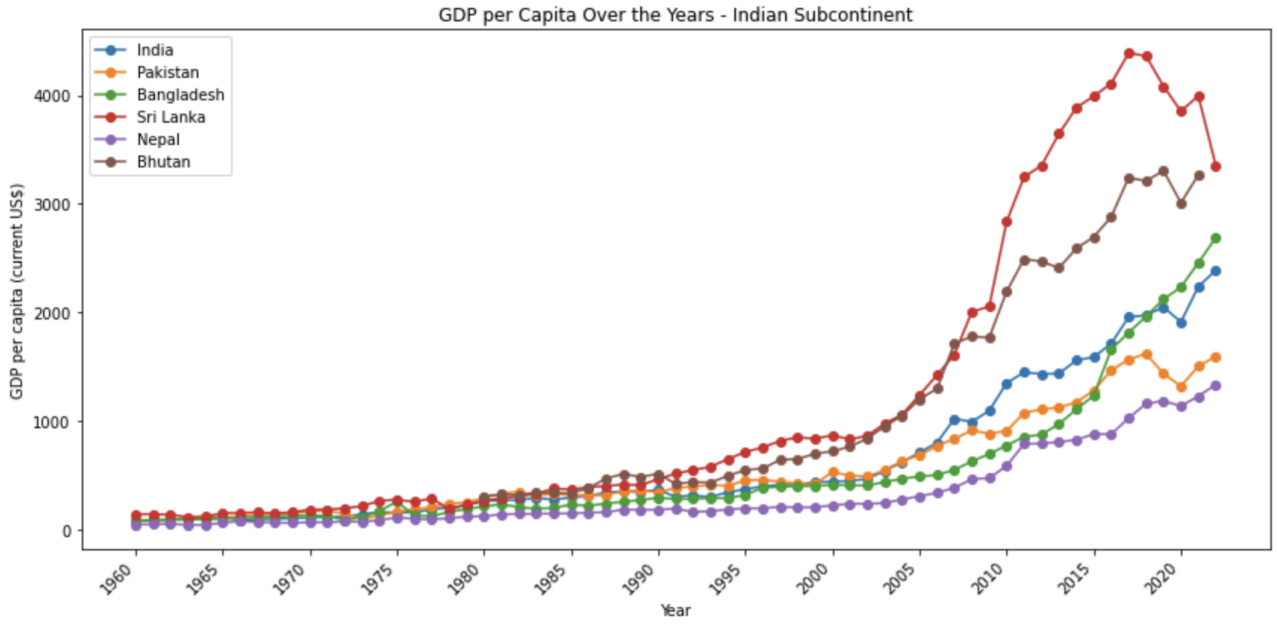
3) GDP per Capita Over the Years - India and China



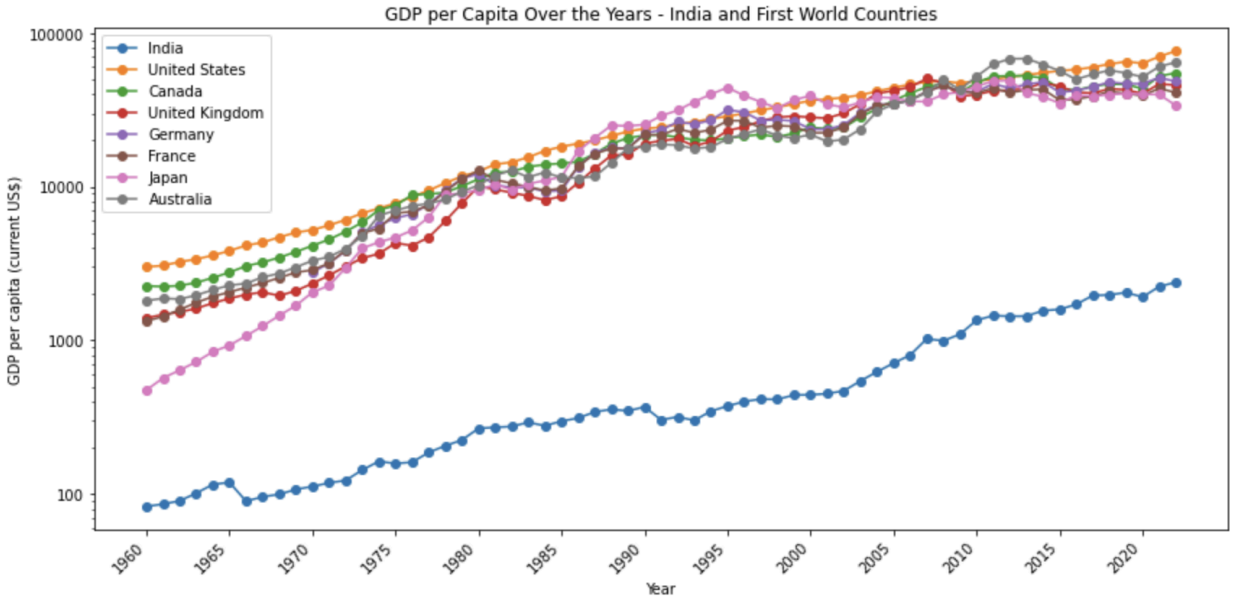
4) GDP per Capita Over the Years - India and United States



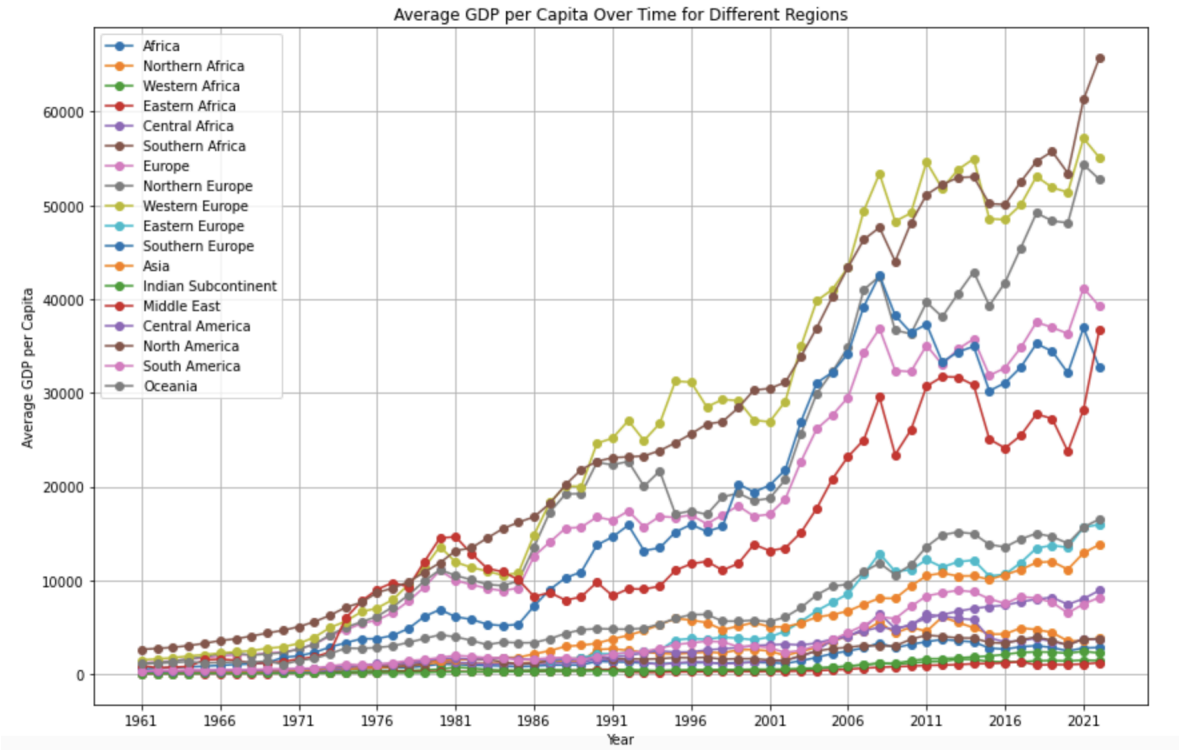
5) GDP per Capita Over the Years - Indian Subcontinent



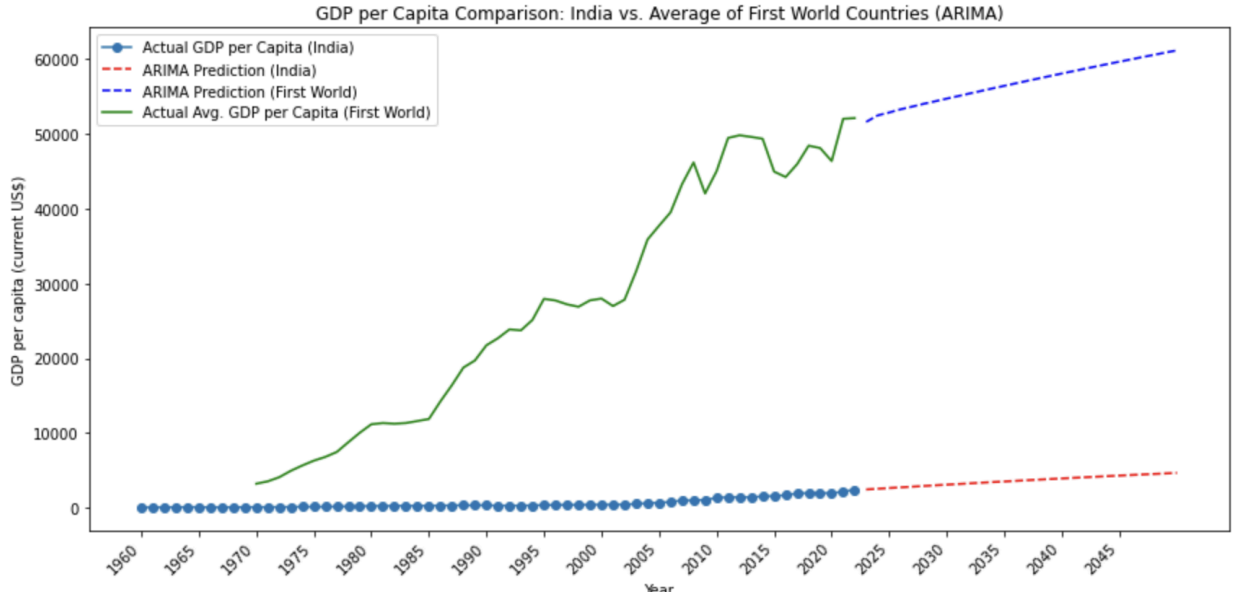
6) GDP per Capita Over the Years - India and First World Countries



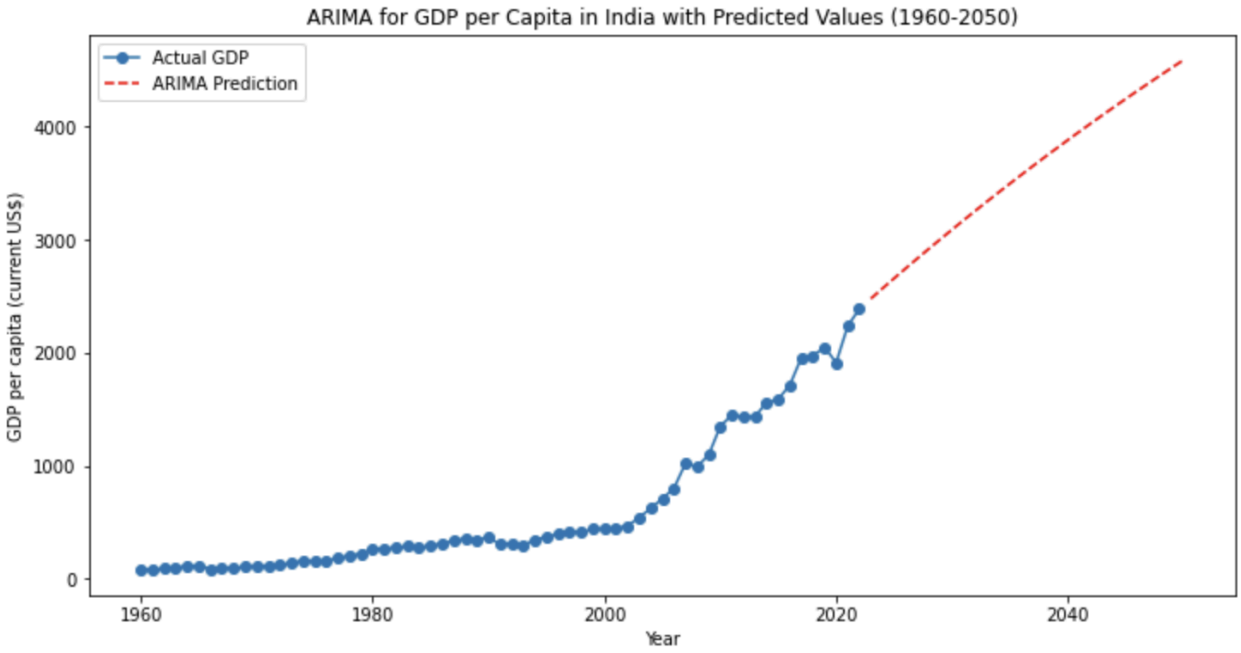
7) Average GDP per Capita Over Time for Different Regions



8) **GDP per Capita Prediction** and Actual GDP per Capita Over the Years - India vs. Average of First World Countries



9) **GDP per Capita Prediction** and Actual GDP per Capita Over the Years - India

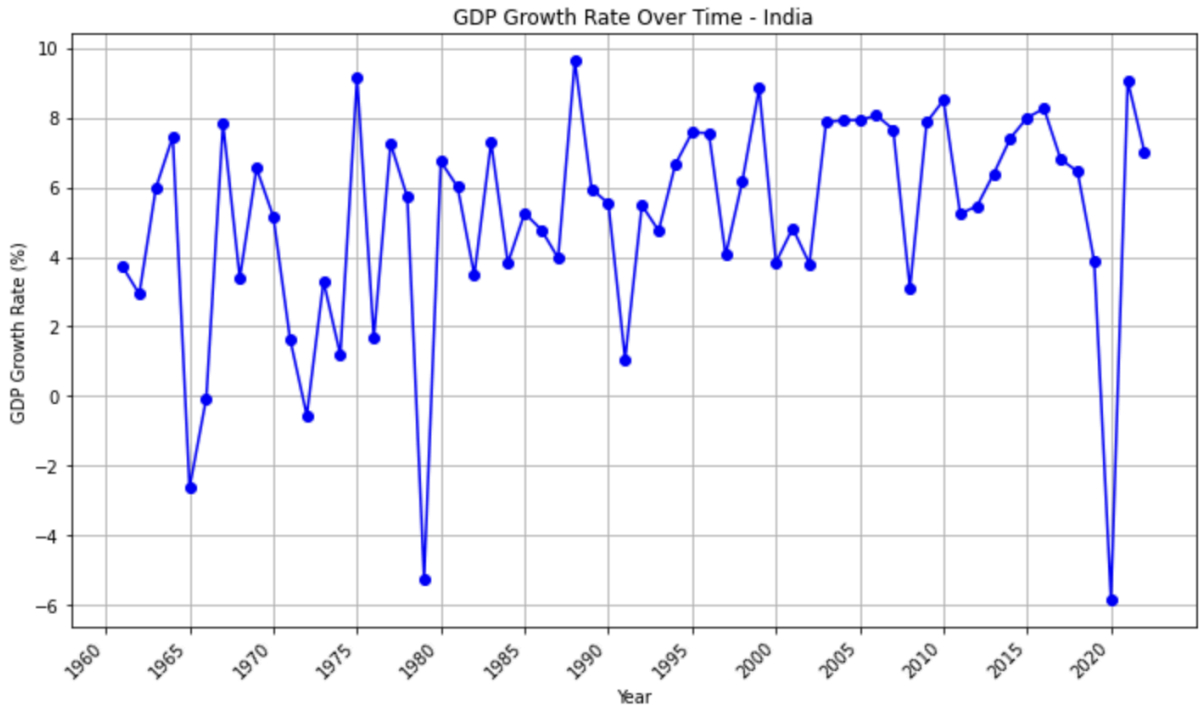


Predicted GDP per Capita for India (2023 to 2050):

	Year	Predicted GDP (India)
0	2023	2476.983413
1	2024	2572.550747
2	2025	2665.941599
3	2026	2758.440568
4	2027	2849.886837
5	2028	2940.315293
6	2029	3029.734161
7	2030	3118.155132
8	2031	3205.589287
9	2032	3292.047645
10	2033	3377.541097
11	2034	3462.080411
12	2035	3545.676235
13	2036	3628.339099
14	2037	3710.079416
15	2038	3790.907481
16	2039	3870.833475
17	2040	3949.867467
18	2041	4028.019410
19	2042	4105.299149
20	2043	4181.716418
21	2044	4257.280843
22	2045	4332.001941
23	2046	4405.889125
24	2047	4478.951701
25	2048	4551.198872
26	2049	4622.639738
27	2050	4693.283298

GDP Growth Rate - Visualization and Prediction

1) GDP Growth Rate Over Time - India



The graph showcasing India's GDP growth rate from 1960 to 2022 can be broken down into distinct periods, each reflecting the country's economic and political landscape:

1960-1980: Steady Growth - Modest growth with government-led industrial policy, Agricultural sector as the backbone.

1980-1990: Pre-Liberalization - Gradual opening and initial steps towards market reforms, Slight uptick in growth rates, setting the stage for liberalization.

1991-2000: Economic Liberalization - Implementation of major economic reforms, Surge in foreign investments and expansion of the service sector, Steadier and higher growth rates compared to previous decades.

2000-2010: Globalization Era - India emerges as a significant global IT player, Consistent high growth, occasionally hitting over 8%.

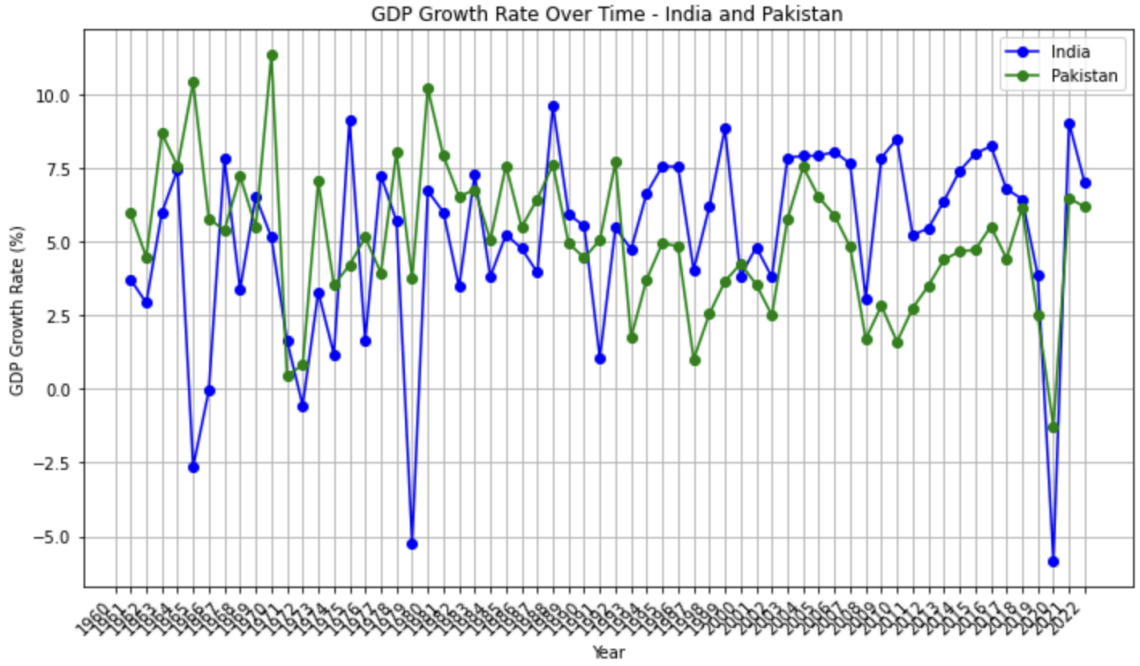
2010-2020: New Challenges and Growth - Fluctuations due to global economic conditions and domestic policy changes , Notable reforms such as GST and demonetization with mixed short-term effects.

2020: COVID-19 Pandemic Impact - Sharp decline reflecting the global economic shutdown Unprecedented negative growth, The negative growth rate is a direct consequence of the pandemic-induced lockdowns, Rapid policy interventions to mitigate economic downturn.

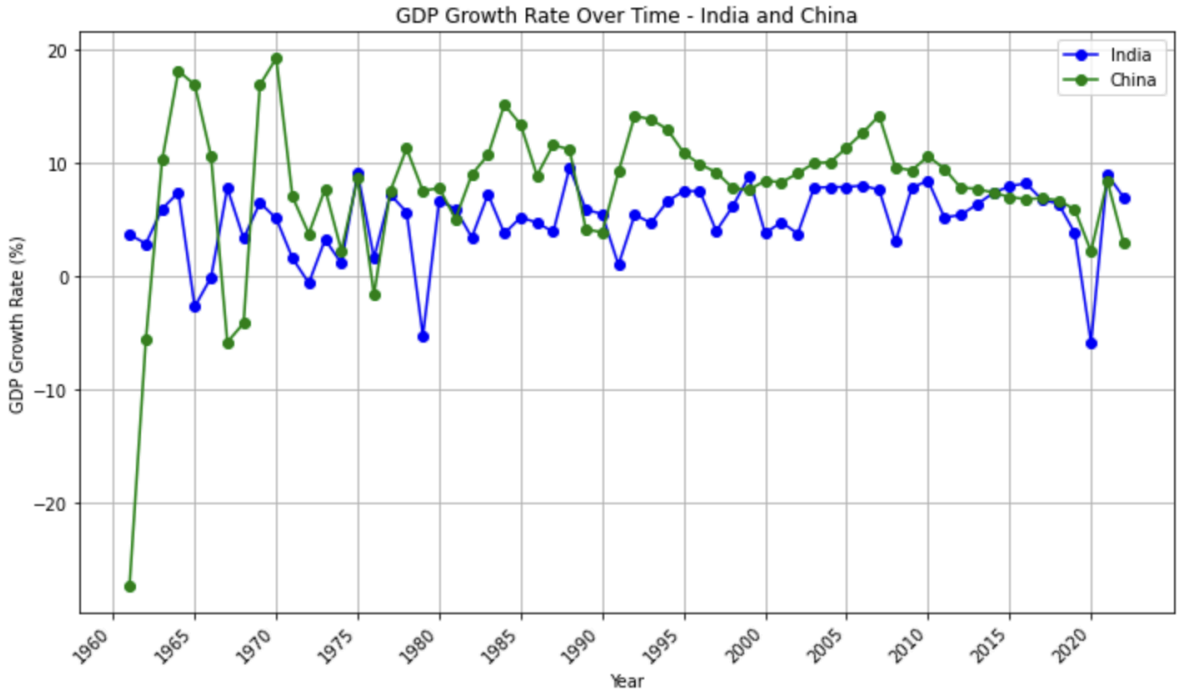
Post-2020: Economic Recovery and Resilience - Quick rebound indicative of strong economic fundamentals and responsive policy measures, Growth rates recovering to pre-pandemic levels, showcasing adaptability

The graph not only reflects economic performance but also has broader implications for social welfare, as periods of higher growth often correlate with improved living standards. Ongoing challenges include addressing income inequality, infrastructure needs, and sustainable development.

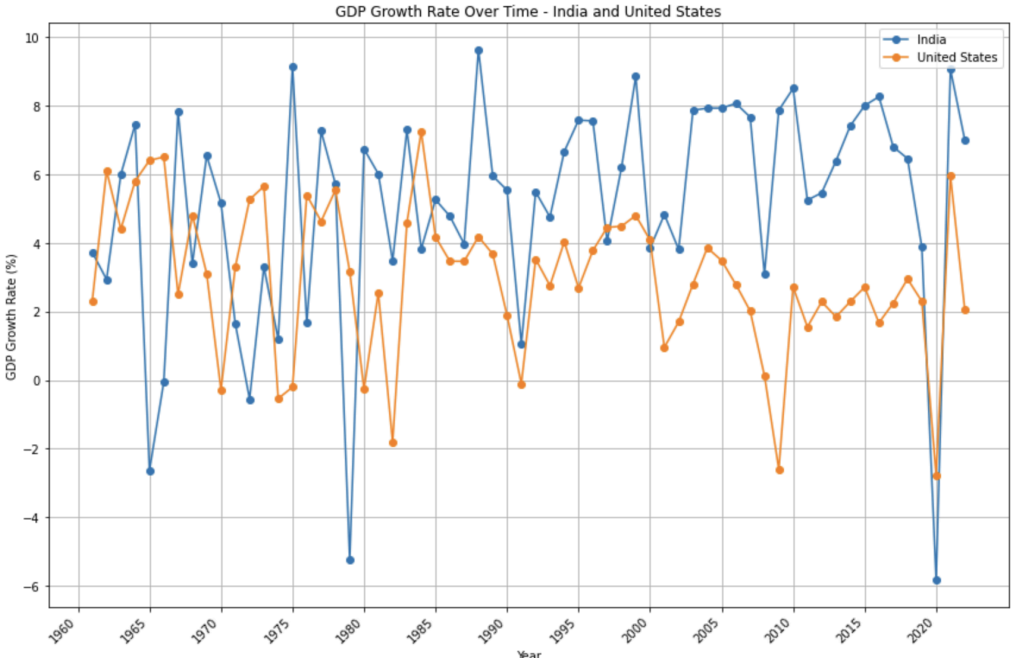
2) GDP Growth Rate Over Time - India and Pakistan



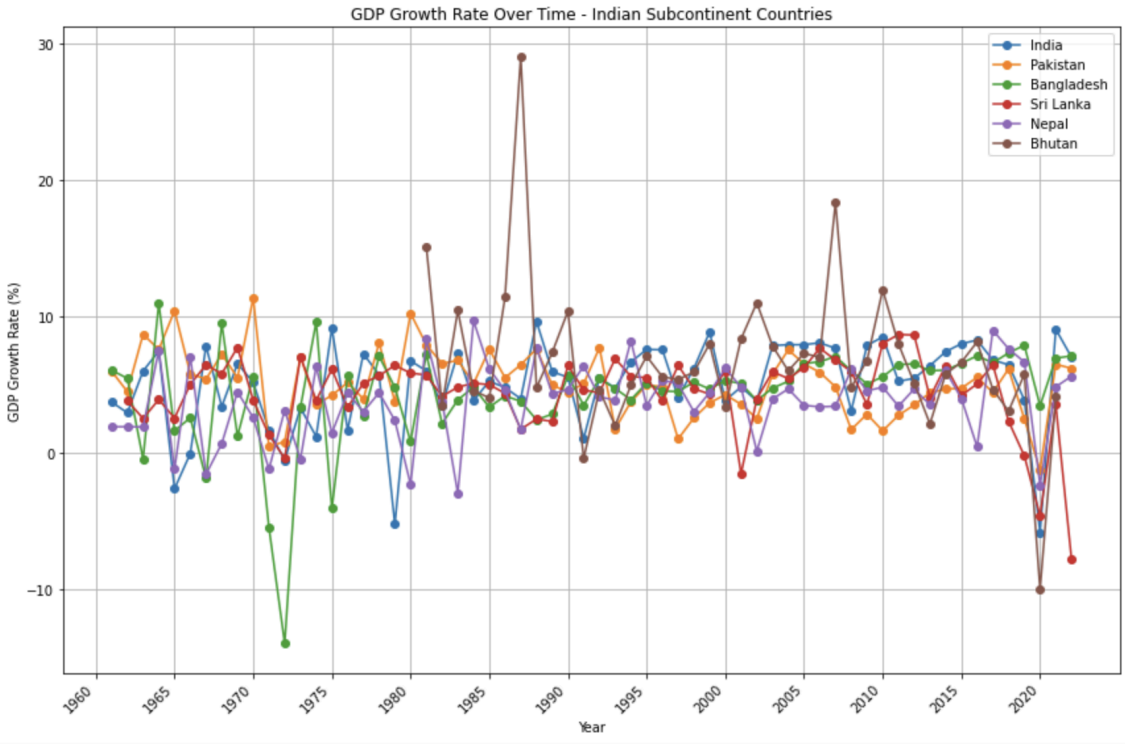
3) GDP Growth Rate Over Time - India and China



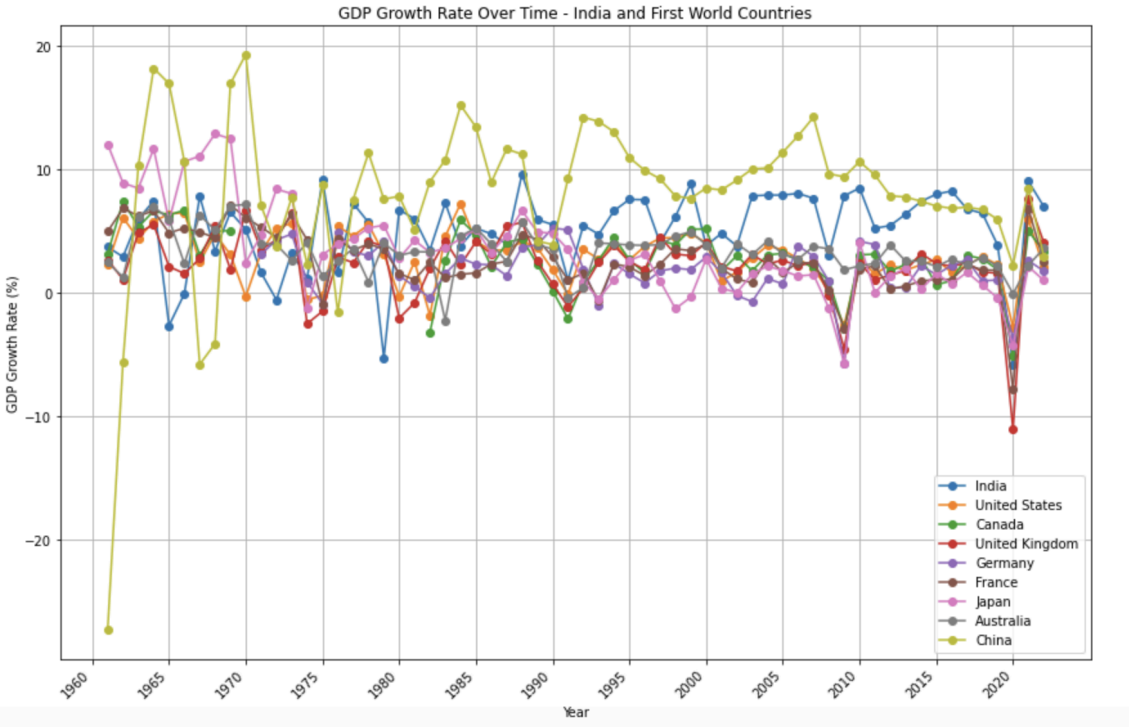
4) GDP Growth Rate Over Time - India and United States



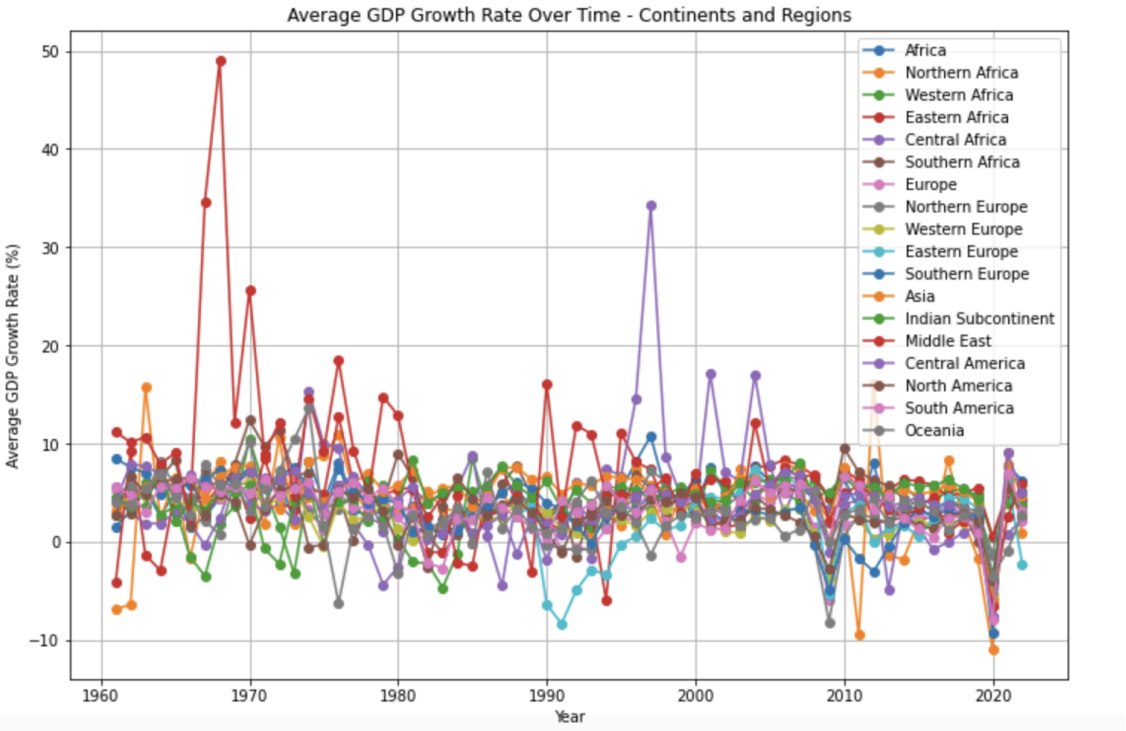
5) GDP Growth Rate Over Time - Indian Subcontinent Countries



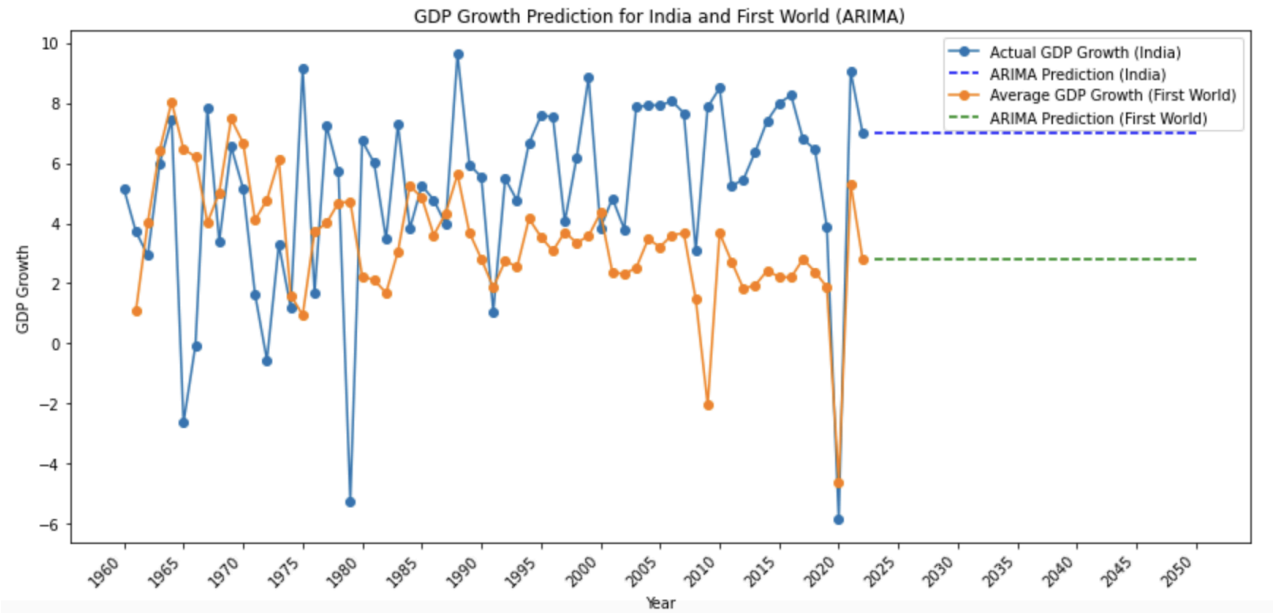
6) GDP Growth Rate Over Time - India and First World Countries



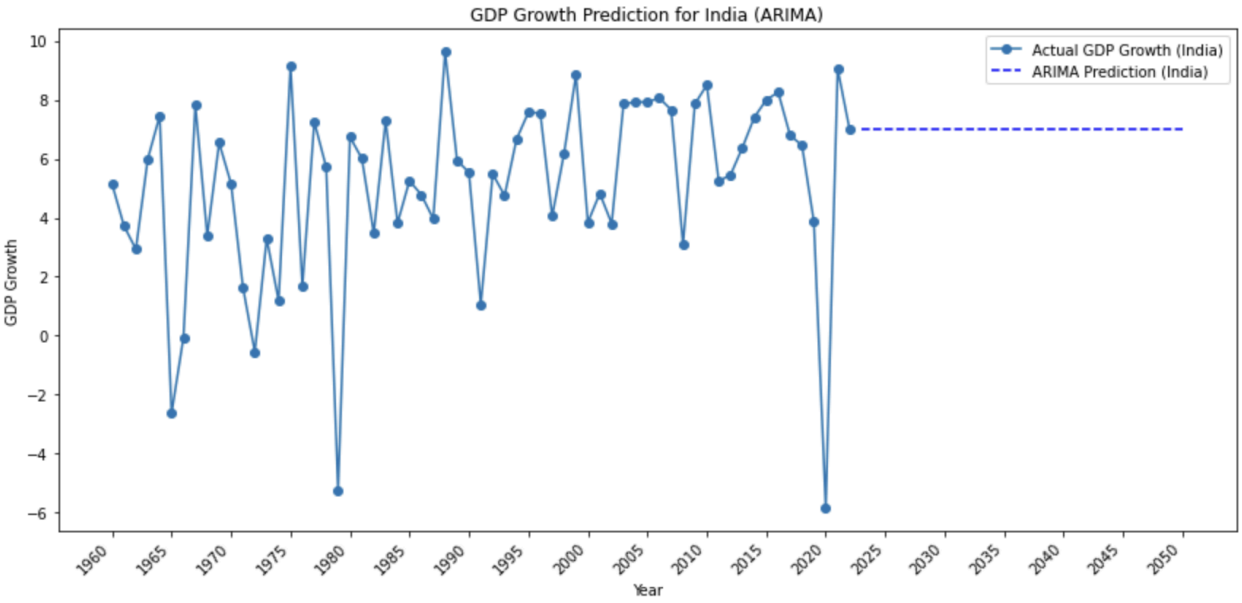
7) Average GDP Growth Rate Over Time - Continents and Regions



8) **GDP Growth Rate Prediction** and Actual GDP Growth Rate Over the Years - India vs. Average of First World Countries



9) **GDP Growth Rate Prediction** and Actual GDP Growth Rate Over the Years - India

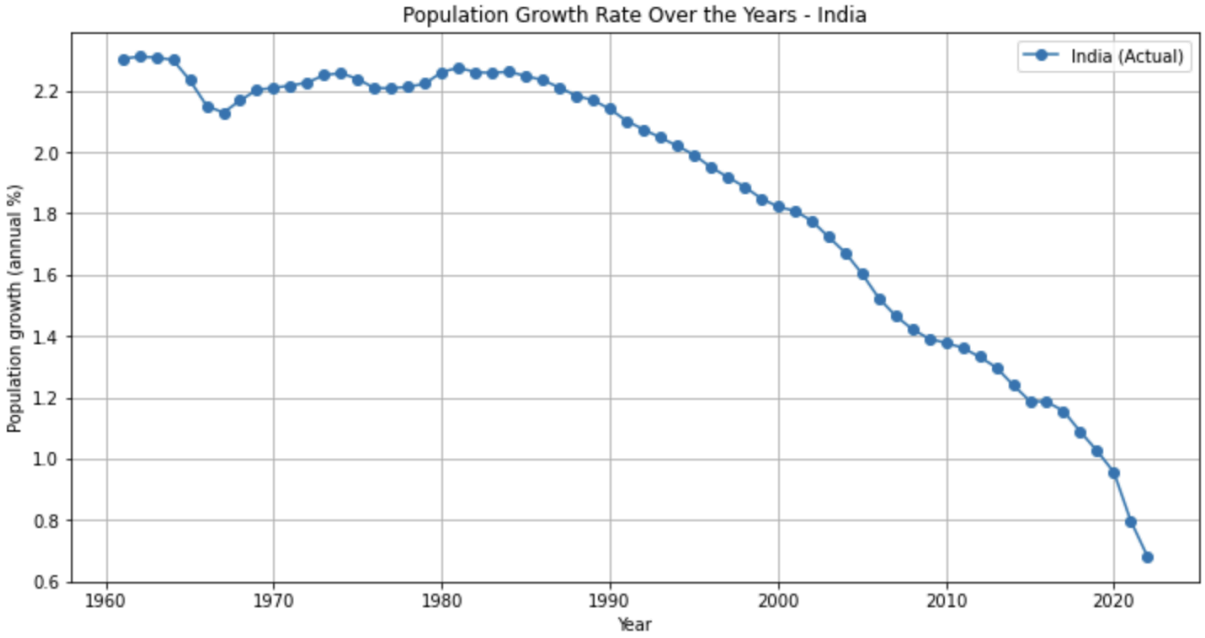


Predicted GDP Growth Rate for India (2023 to 2050):

[7.00295154 7.00295154 7.00295154 7.00295154 7.00295154 7.00295154
 7.00295154 7.00295154 7.00295154 7.00295154 7.00295154 7.00295154
 7.00295154 7.00295154 7.00295154 7.00295154 7.00295154 7.00295154
 7.00295154 7.00295154 7.00295154 7.00295154 7.00295154 7.00295154
 7.00295154 7.00295154 7.00295154 7.00295154]

<u>Population Growth Rate</u> - Visualization and Prediction

1) Population Growth Rate Over the Years - India



This line graph illustrates the trend in India's population growth rate on an annual basis from the 1960s through to 2022. The population growth rate is a vital indicator in demographic studies, reflecting the rate at which the number of individuals in a population increases in a year as a percentage of the total population.

Stable High Growth (1960s-1970s): In the initial decades (1960s to 1970s), the growth rate was stable at just above 2%. This suggests a high birth rate and minimal impact from family planning initiatives during that period.

Gradual Decline Begins (1980s-1990s): A gradual decline started from the early 1980s. This could be related to the inception of various family planning programs and an increasing awareness of population issues.

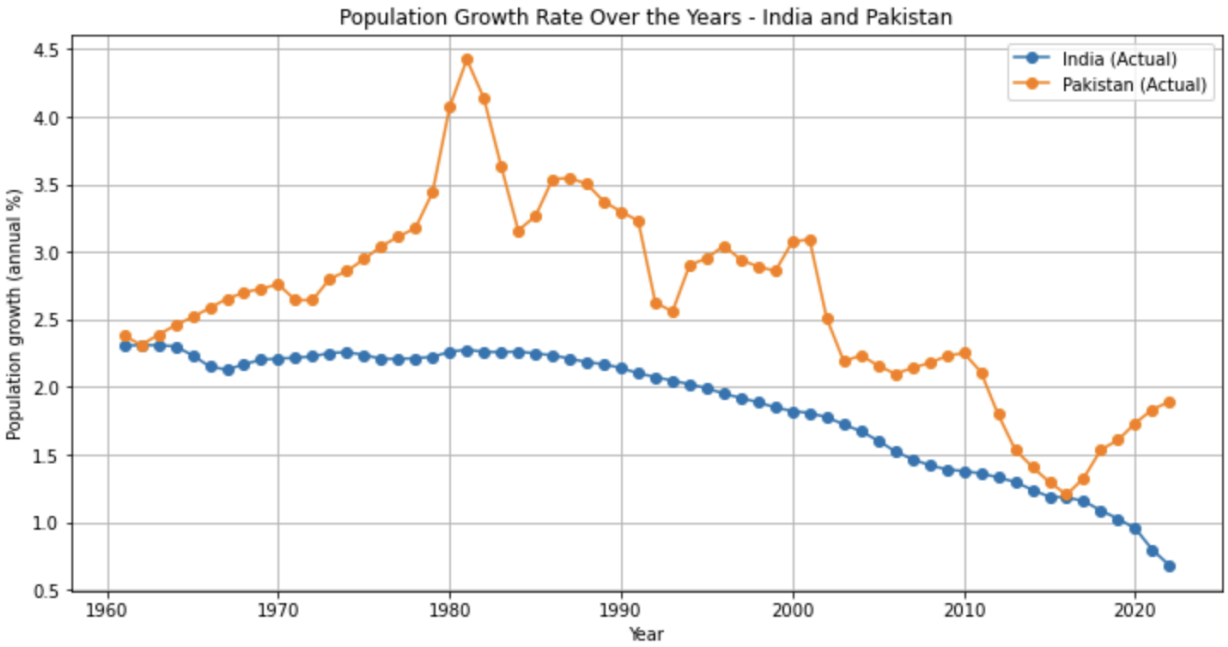
Steady Decline (2000s): The decline in growth rate continued steadily through the 2000s. This period may correspond with improved access to education, healthcare, and contraception, contributing to lower fertility rates.

Significant Decrease (2010s-2020): There is a noticeable steeper decline from the 2010s onwards. The factors behind this could include continued government interventions, socio-economic changes, and a demographic transition to lower fertility and mortality rates.

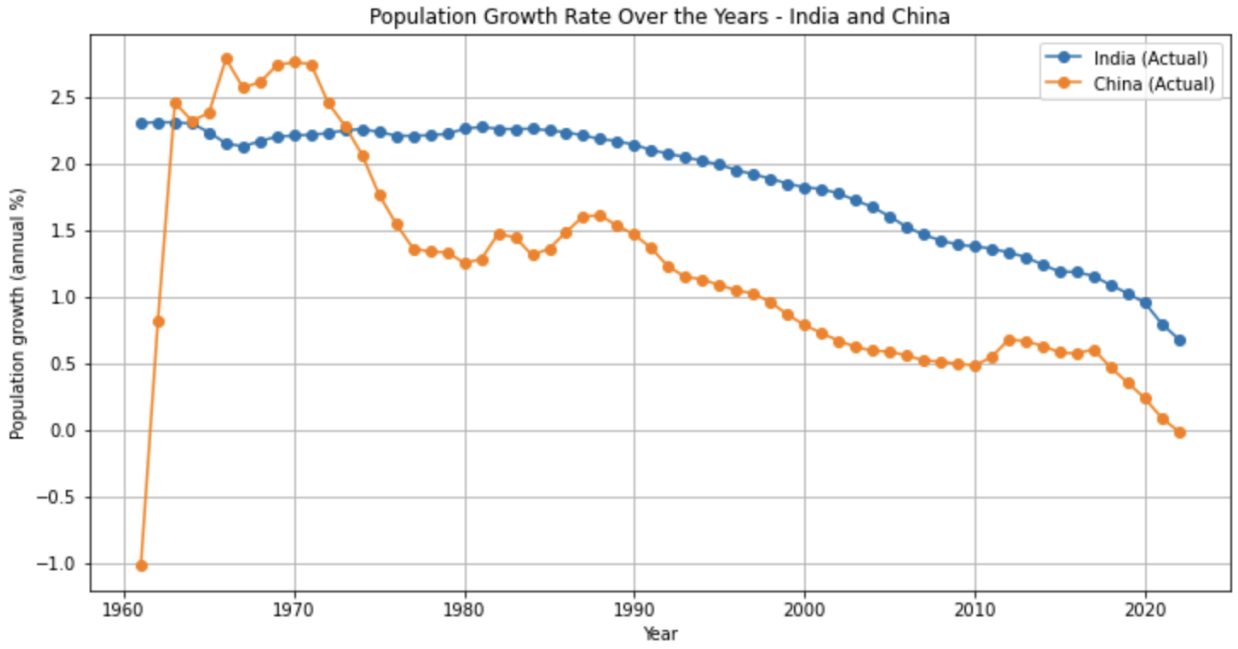
Below Replacement Level (Approaching 2020): Approaching 2020, the growth rate dips towards 1%, indicating a shift to near replacement-level fertility. This is where the birth rate is close to the death rate, and the population growth rate approaches zero, which is often seen as a demographic indicator of a developing economy transitioning to a developed one.

These trends reflect the changing demographic patterns in India and hint at the potential for a demographic dividend if the declining growth rate leads to a larger proportion of the working-age population. However, it also presents challenges, such as the need for effective policy planning to manage aging populations in the future.

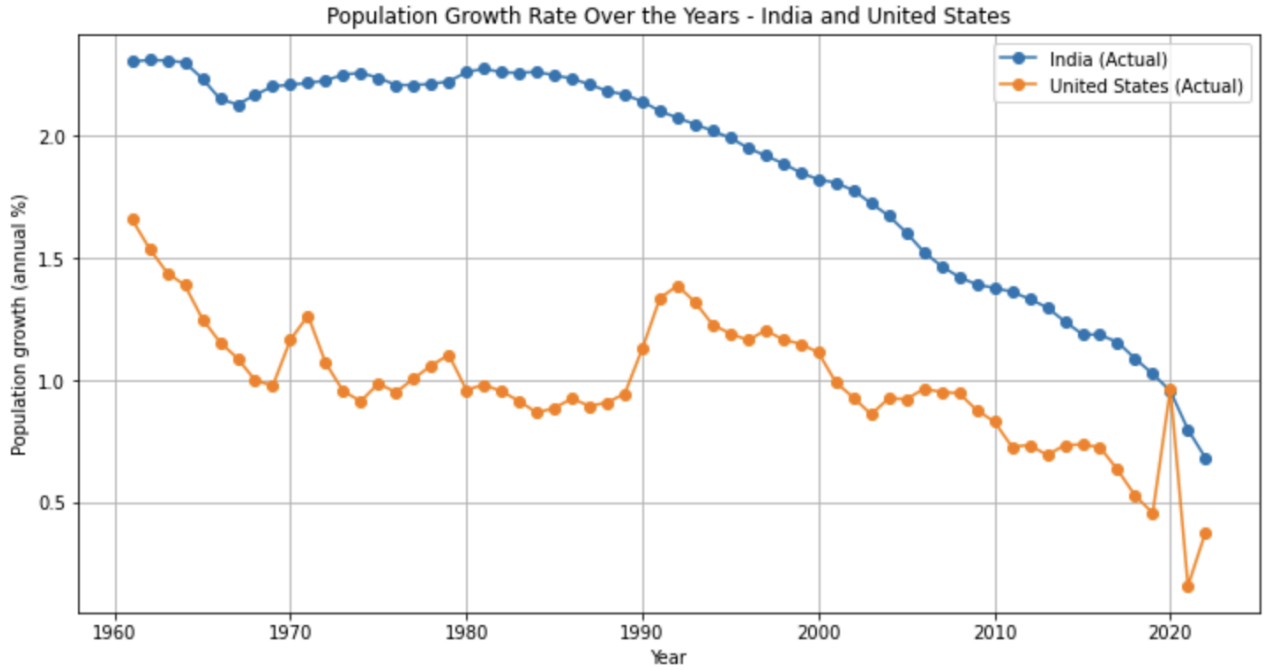
2) Population Growth Rate Over the Years - India and Pakistan



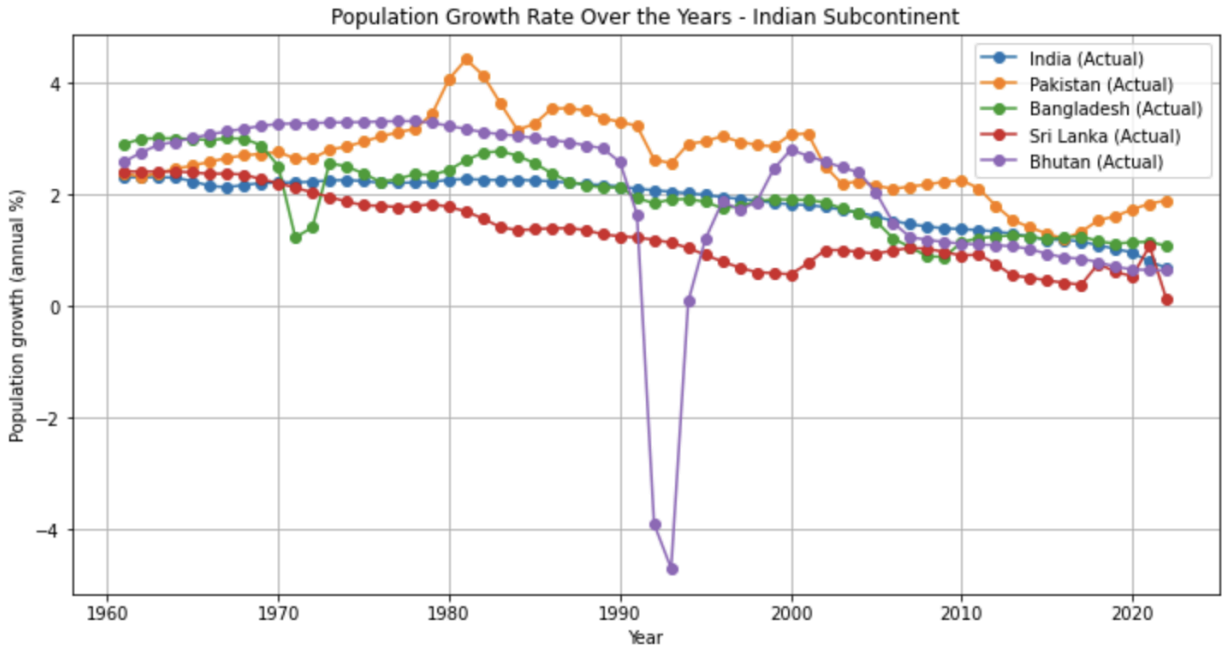
3) Population Growth Rate Over the Years - India and China



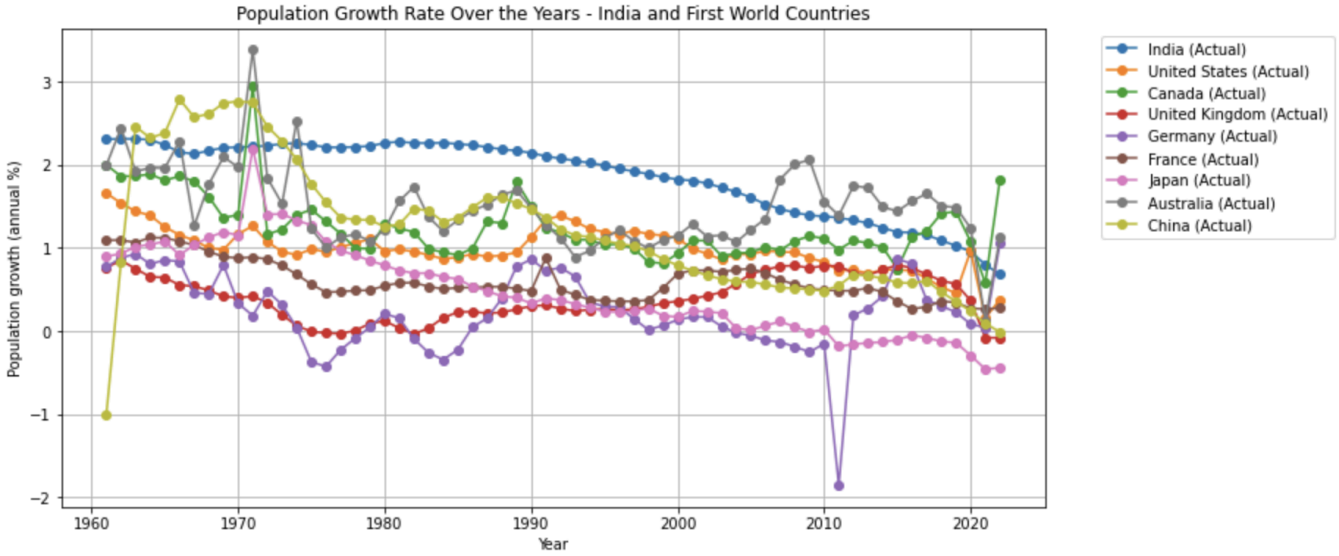
4) Population Growth Rate Over the Years - India and United States



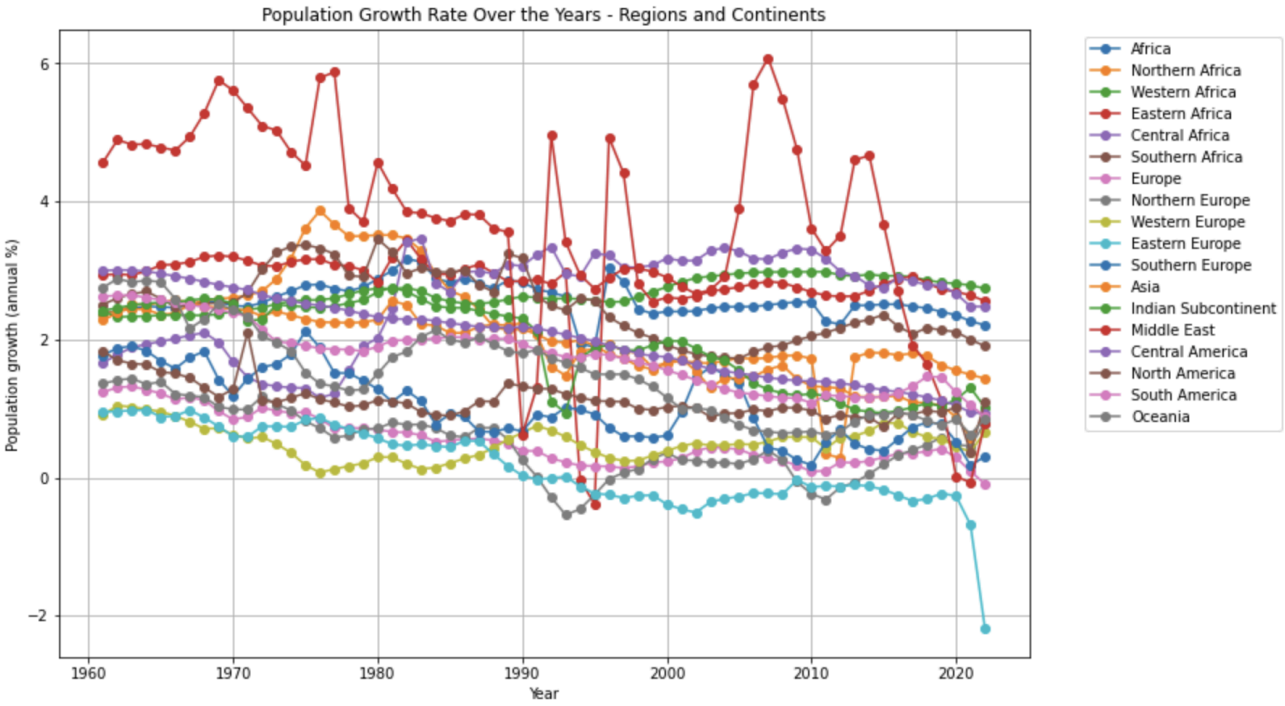
5) Population Growth Rate Over the Years - Indian Subcontinent



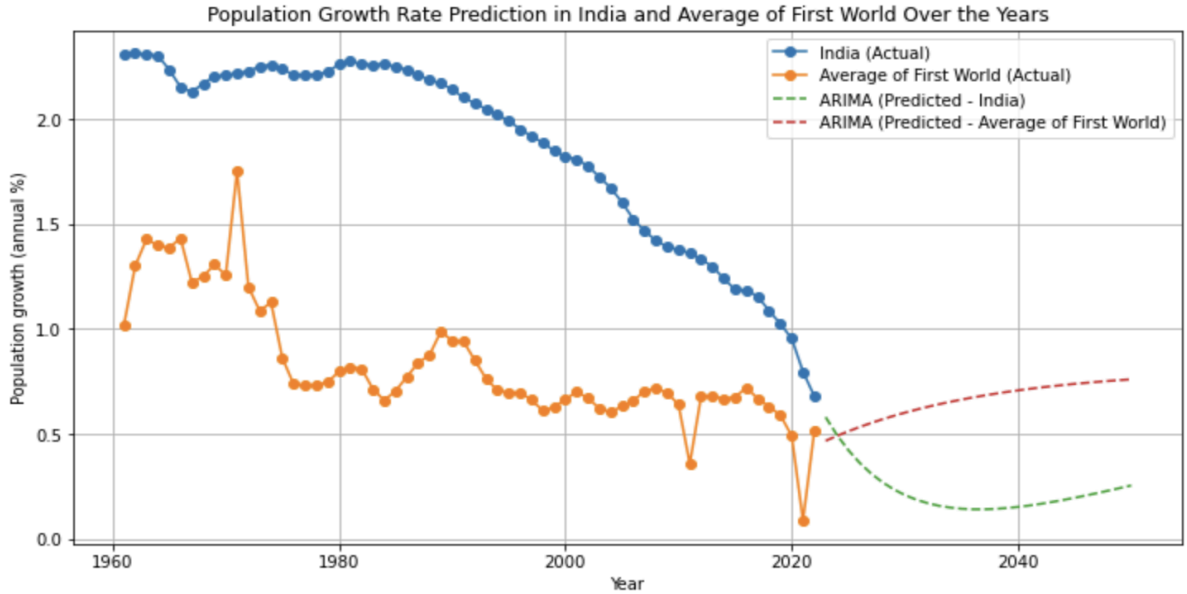
6) Population Growth Rate Over the Years - India and First World Countries



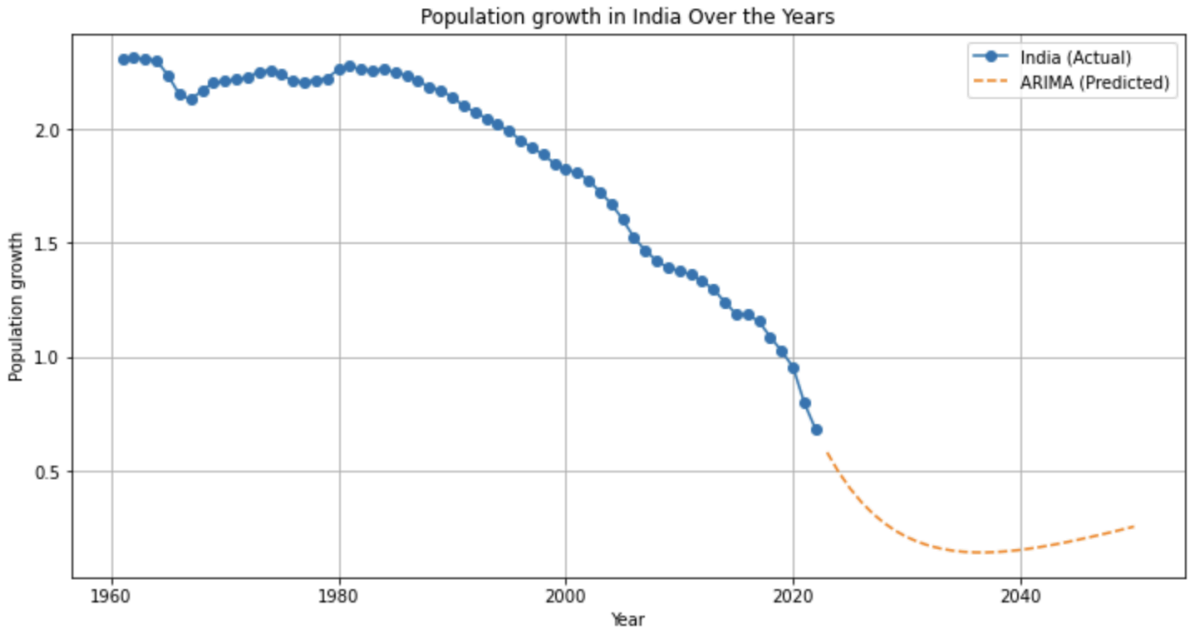
7) Population Growth Rate Over the Years - Regions and Continents



8) **Population Growth Rate Prediction** and Actual Population Growth Rate Over the Years - India vs. Average of First World Countries



9) **Population Growth Rate Prediction** and Actual Population Growth Rate Over the Years - India

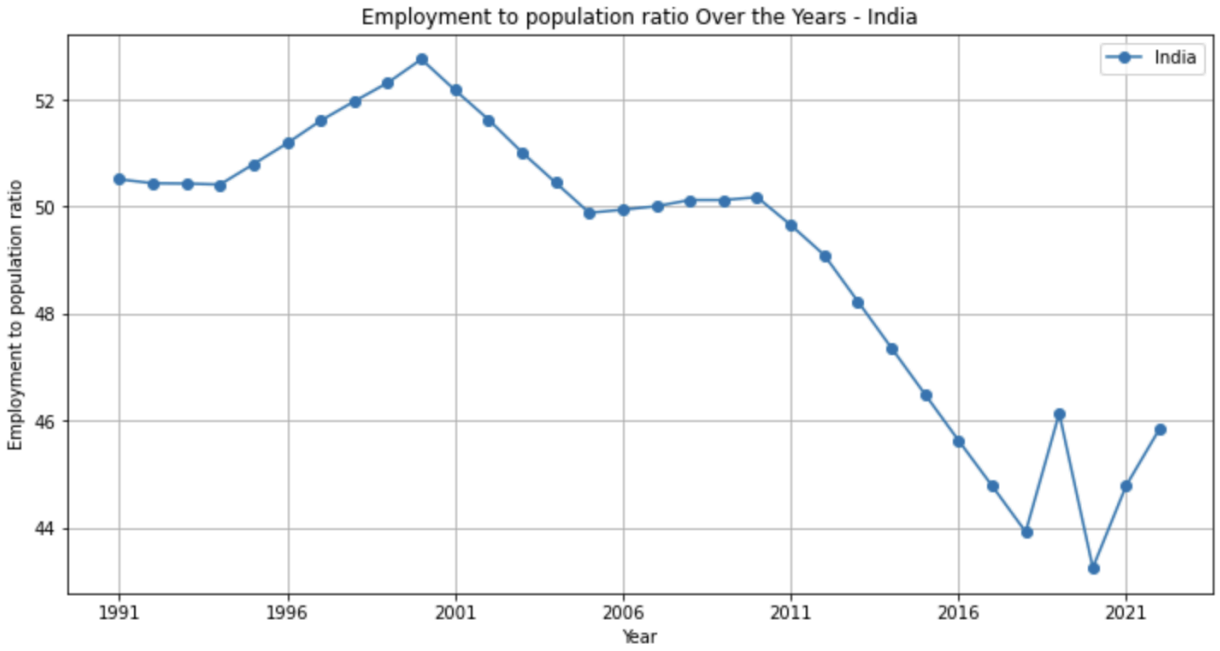


Predicted Population Growth Rate for India (2023 to 2050):

Year 2023: 0.5806310096834211
Year 2024: 0.4958350382220702
Year 2025: 0.4240957518884829
Year 2026: 0.36375856317975297
Year 2027: 0.31337420831330975
Year 2028: 0.2716733325156022
Year 2029: 0.23754422013084797
Year 2030: 0.21001328042427825
Year 2031: 0.1882279481026874
Year 2032: 0.171441699765851
Year 2033: 0.15900092447266867
Year 2034: 0.15033341900166897
Year 2035: 0.14493830677281028
Year 2036: 0.14237720427231593
Year 2037: 0.142266480619208
Year 2038: 0.14427047501208867
Year 2039: 0.14809555353128645
Year 2040: 0.15348490143716176
Year 2041: 0.16021395995637966
Year 2042: 0.16808642780886118
Year 2043: 0.17693075759566068
Year 2044: 0.18659708581459733
Year 2045: 0.19695454284716085
Year 2046: 0.20788889589941095
Year 2047: 0.2193004836972834
Year 2048: 0.23110240683456085
Year 2049: 0.24321894213883155
Year 2050: 0.2555841533350882

Employment to Population Ratio, 15+, total (%) - Visualization and Prediction

1) Employment To Population Ratio Over the Years - India



The graph presents the employment-to-population ratio in India from 1991 to 2022. This ratio is a key labor market indicator that provides insights into the ability of an economy to create employment.

Initial Increase (1991-2005): There's a rising trend from 1991 until about 2005, with the ratio peaking just above 52%. This period likely reflects economic liberalization effects, resulting in job creation and economic growth.

Declining Trend (2006-2017): Post-2005, a significant and consistent decline is observed, with the ratio dropping to nearly 44% by 2017. The decline could signify job losses, increased automation, demographic changes, or underemployment

Volatility and Recovery (2018-2021): A notable volatility in the ratio is seen from 2018 onwards, with sharp declines and recoveries. These fluctuations might be due to economic shocks, policy changes, or external factors like trade dynamics and global economic trends.

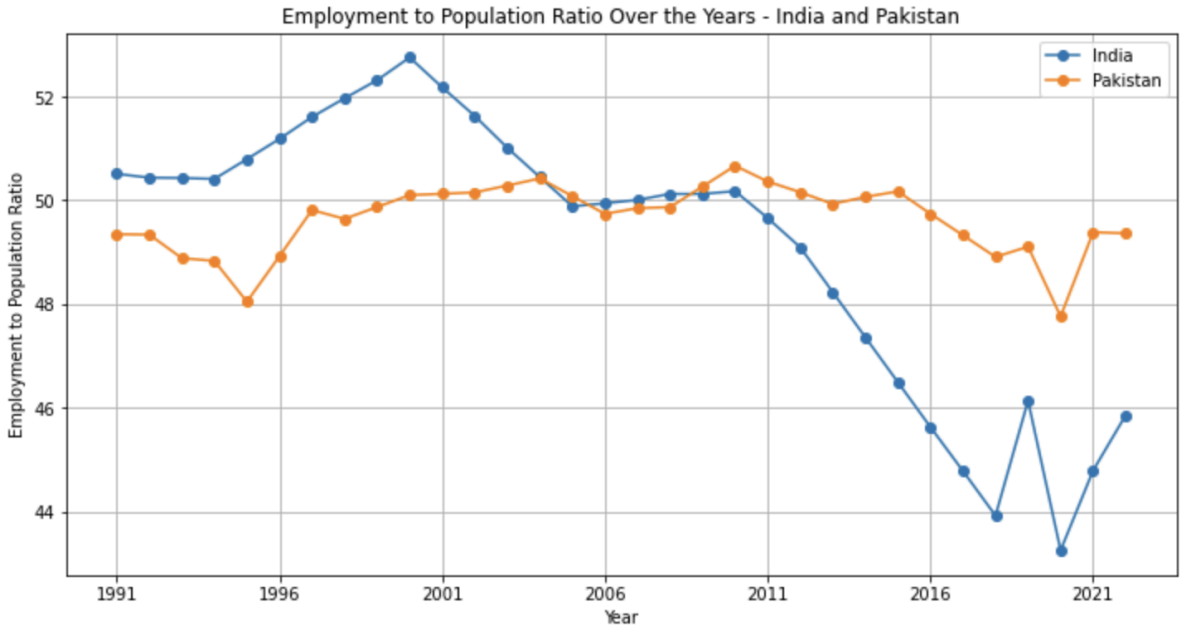
Sharp Drops (Yearly Observations): Specific years show sharp declines, such as around 2011 and 2016, potentially due to structural changes or economic events.

Pandemic Impact (2020 Onwards): The ratio plummets around 2020, which can be attributed to the COVID-19 pandemic's impact on the economy leading to job losses.

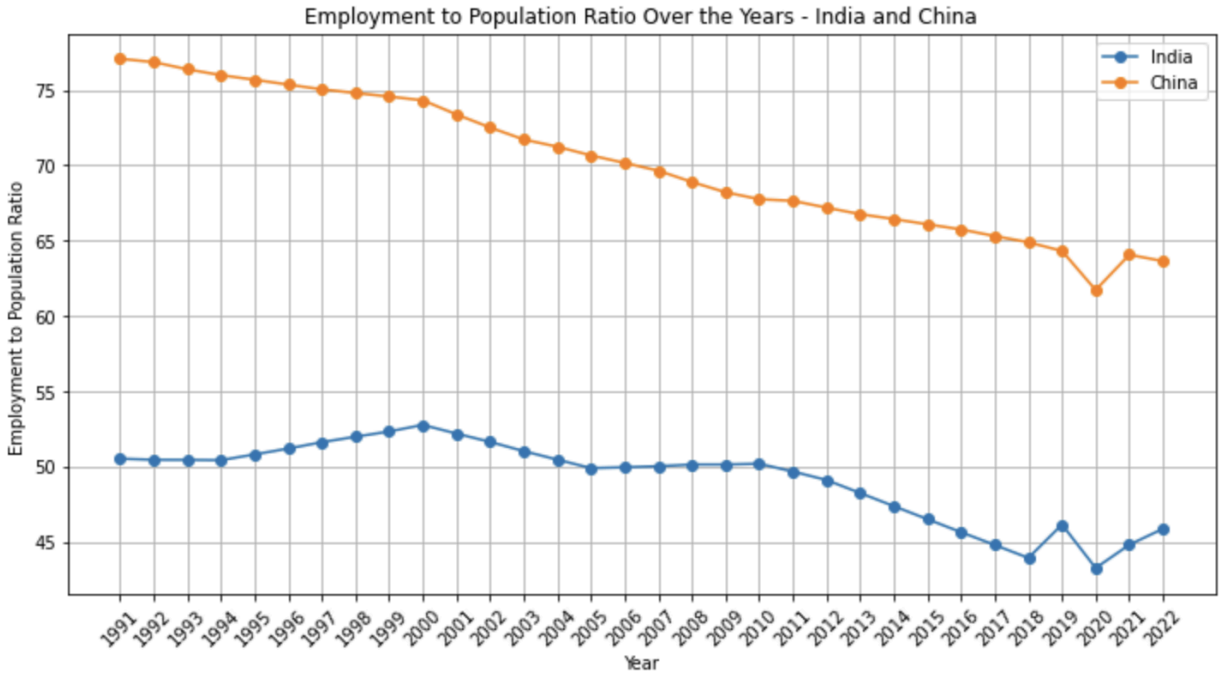
Resilience (2021): A slight recovery in 2021 suggests resilience or corrective measures, although it does not return to previous levels.

The declining trend despite initial growth could indicate a mismatch between the number of working-age individuals and available jobs, possibly exacerbated by technological change and economic challenges. The volatility in the later years, including the sharp drop due to the pandemic, highlights the vulnerability of employment to external shocks. It also suggests the need for adaptive economic policies to stabilize and grow employment opportunities in India.

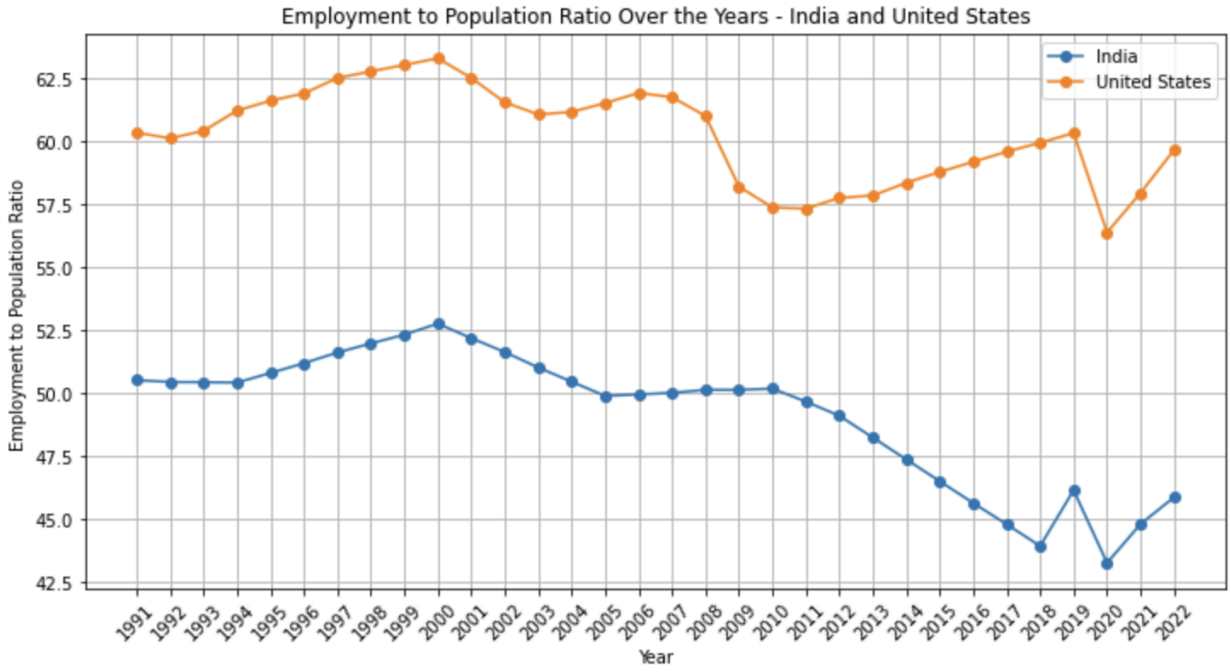
2) Employment to population ratio Over the Years - India and Pakistan



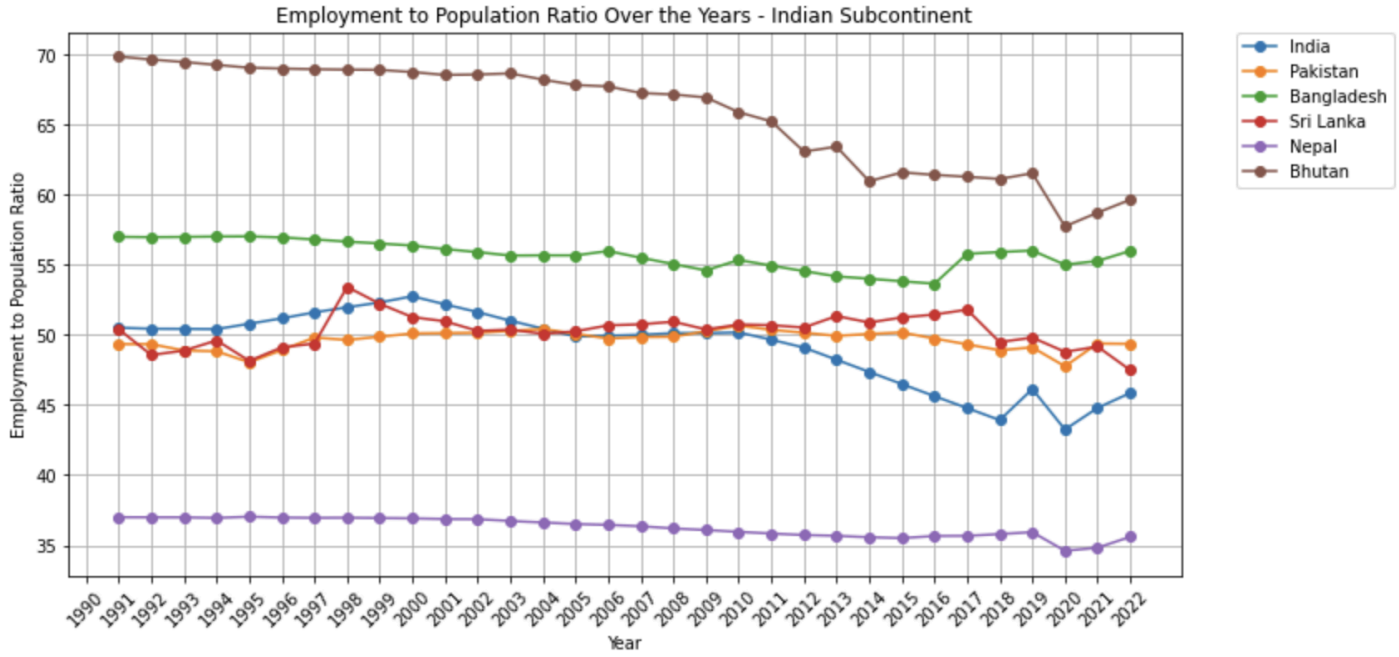
3) Employment to population ratio Over the Years - India and China



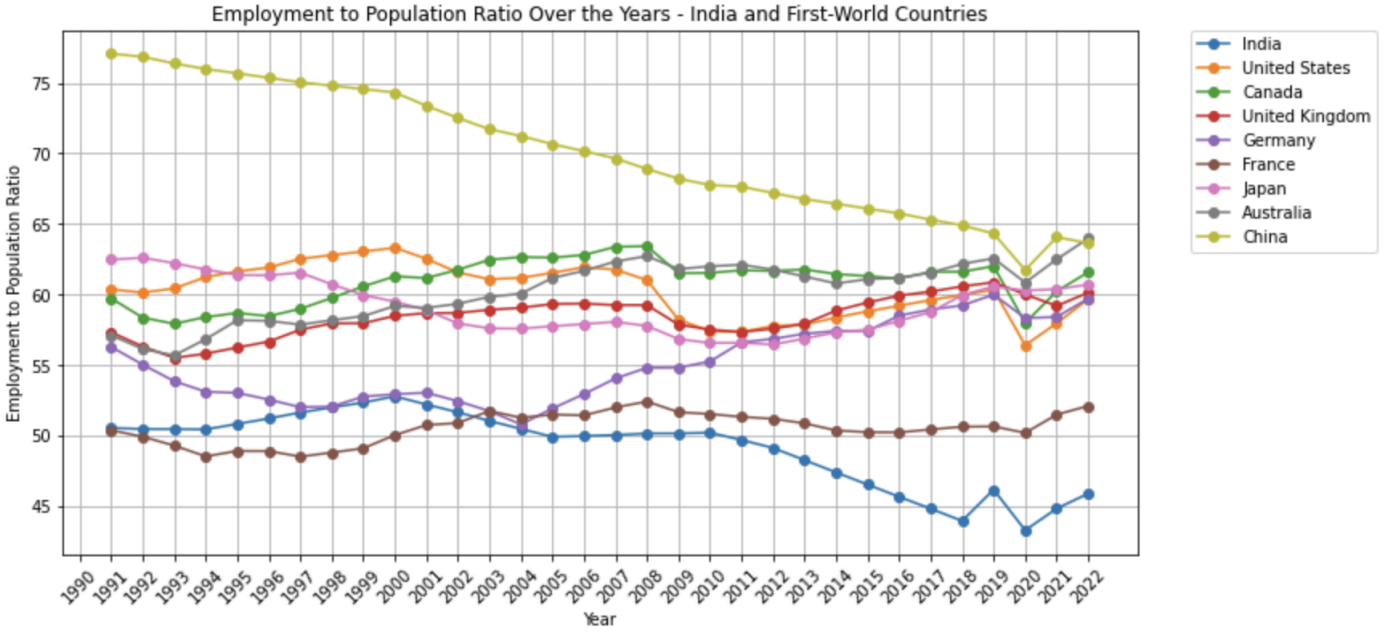
4) Employment to population ratio Over the Years - India and United States



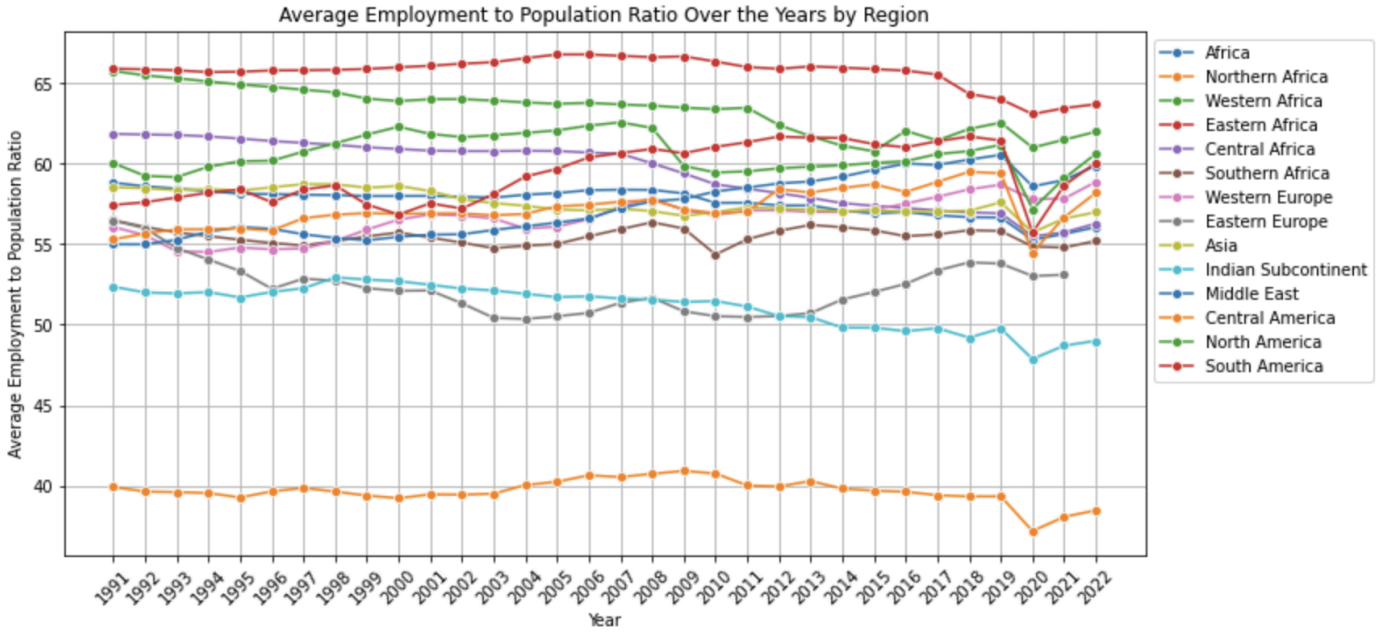
5) Employment to population ratio Over the Years - Indian Subcontinent



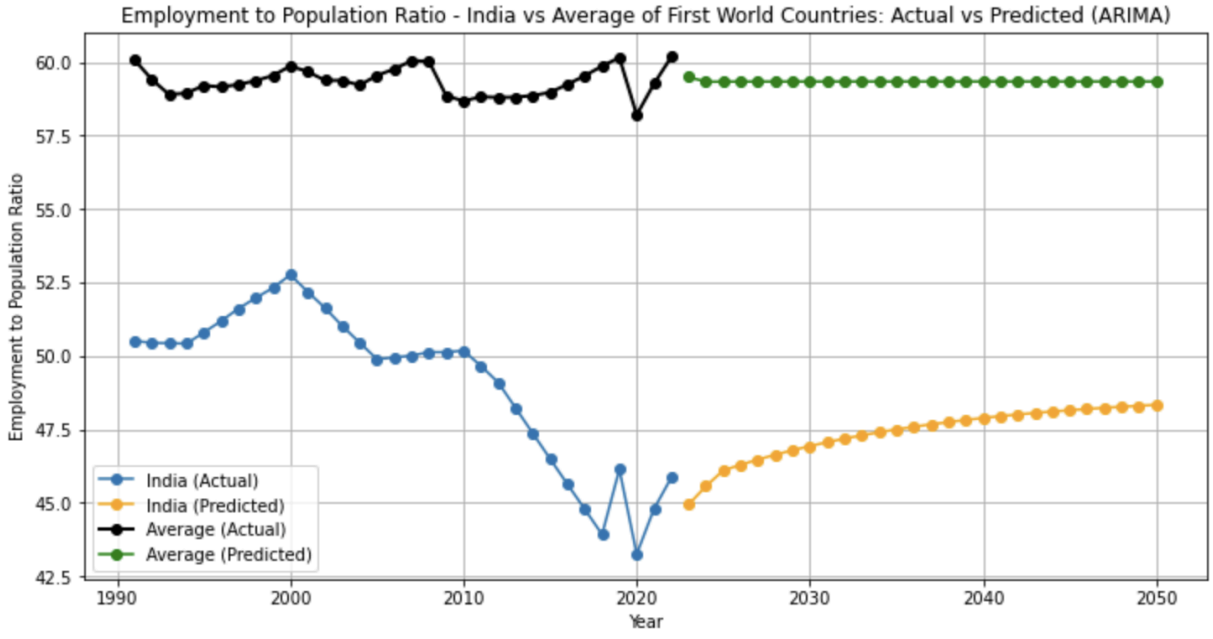
6) Employment to Population Ratio Over the Years - India and First-World Countries



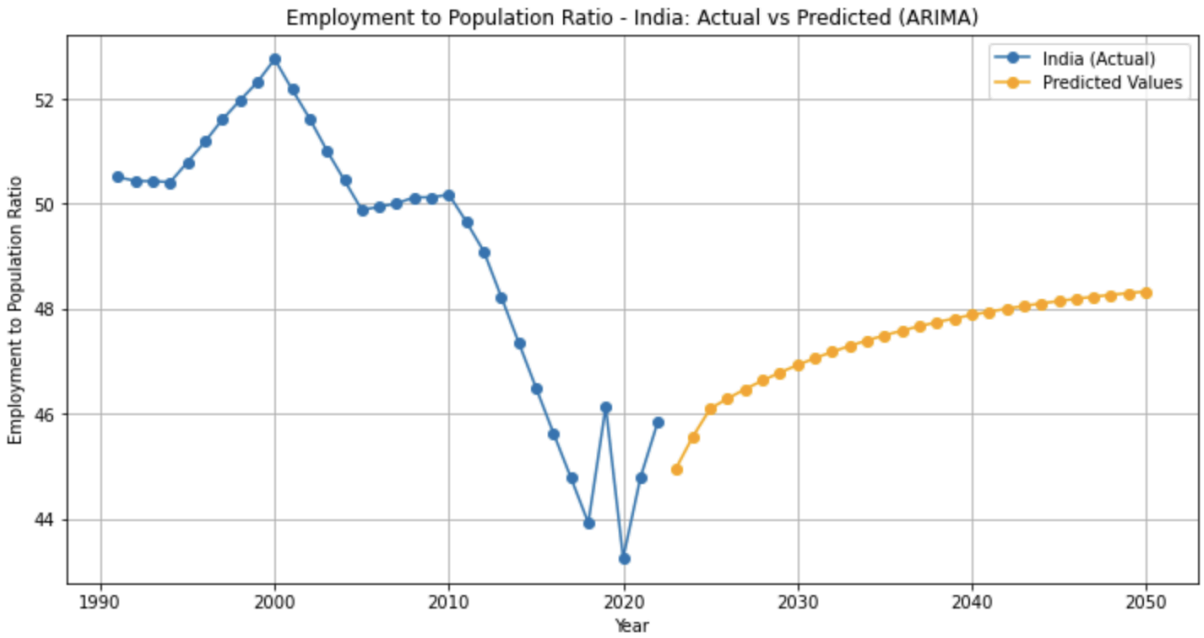
7) Employment to Population Ratio Over the Years - Regions and Continents.



8) **Employment to Population Ratio Prediction** and Actual Employment to Population Ratio Over the Years - India vs. Average of First World Countries



9) **Employment to Population Ratio Prediction** and Actual Employment To Population Ratio Over the Years - India

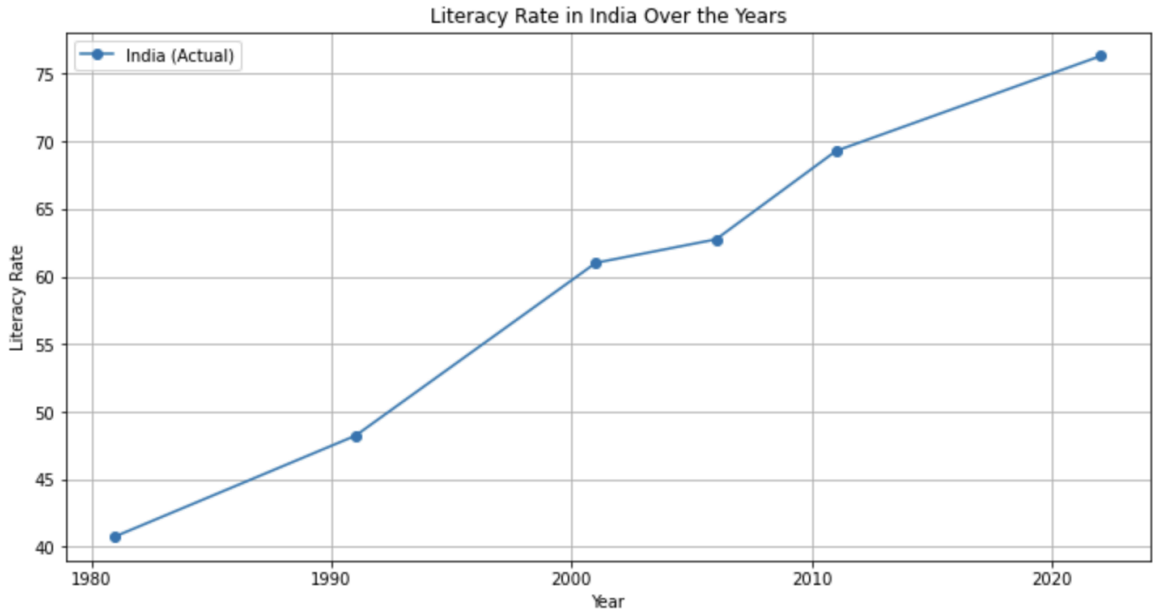


Predicted Employment to Population Ratio for India (2023 to 2050):

[44.94188943 45.56675569 46.10089817 46.2924542 46.47003128
46.63464954 46.78725466 46.9287233 47.05986817 47.18144263
47.29414511 47.39862304 47.49547661 47.58526222 47.66849566
47.74565507 47.81718372 47.88349251 47.94496237 48.00194641
48.05477201 48.10374261 48.14913955 48.19122361 48.23023656
48.2664025 48.29992921 48.33100929]

Literacy rate, adult total (% of people ages 15 and above) - Visualization and Prediction

1) Literacy Rate Over the Years - India



The graph traces India's literacy rate from 1980 to 2021, showcasing a significant upward trajectory:

1980s: The literacy rate begins under 50%, indicating a large non-literate population at the time.

1990s: A notable increase, likely reflecting national policies to promote education and literacy.

2000s: Continued growth aligns with India's rapid economic development and educational reforms.

2010-2020: The rate ascends closer to 75%, suggesting effective educational policies and improved access to education.

Post-2010: The literacy rate's ascent slows, hinting at approaching saturation or emerging challenges in further improving literacy.

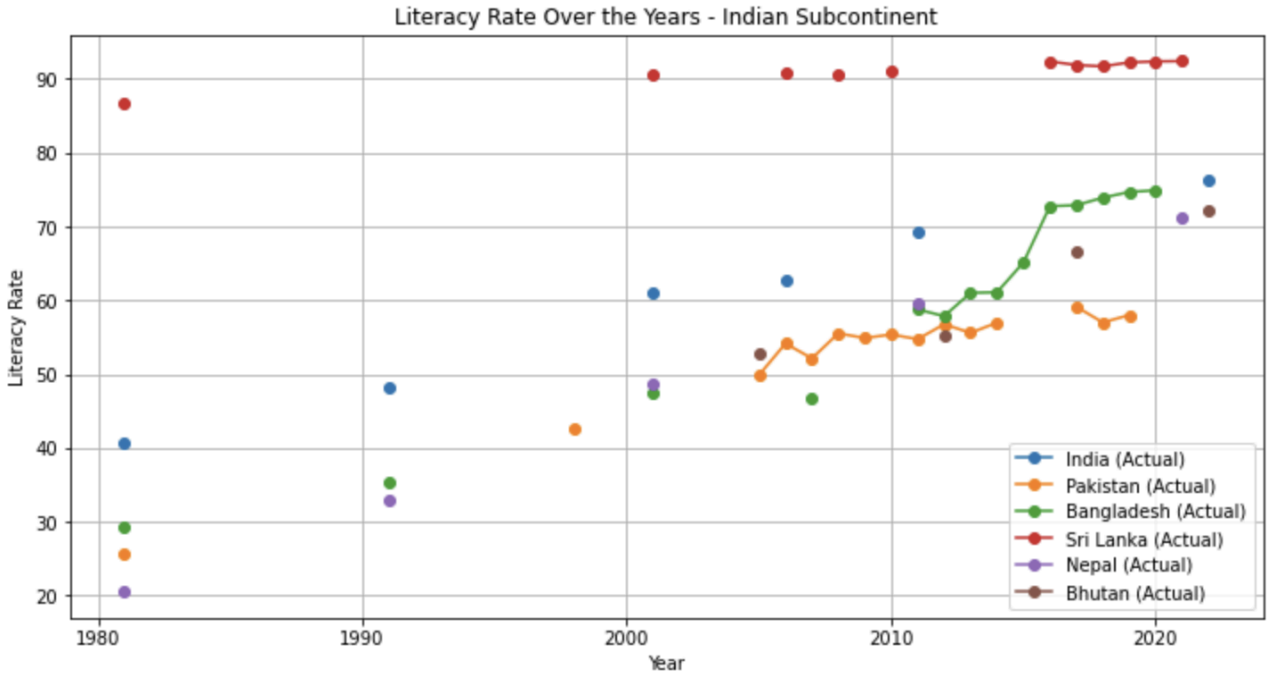
2021: The graph ends just below 80%, not reflecting potential disruptions such as the COVID-19 pandemic.

This positive trend indicates an ongoing success in educational initiatives and greater access to schooling and a substantial shift in India's educational landscape, which has significant implications for the country's socio-economic development, and its workforce's potential.

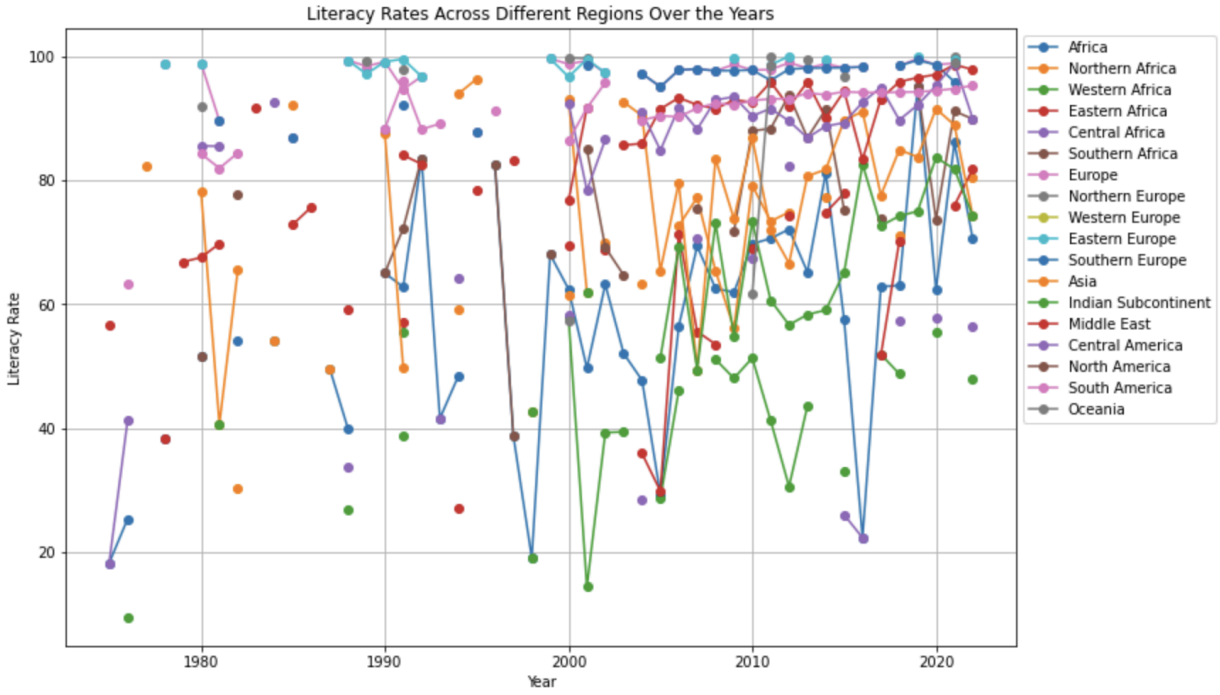
However, the data does not reveal the quality of education, gender disparities, or regional variations, which are crucial for comprehensive policy-making.

2) Literacy Rate Over the Years - India and Pakistan

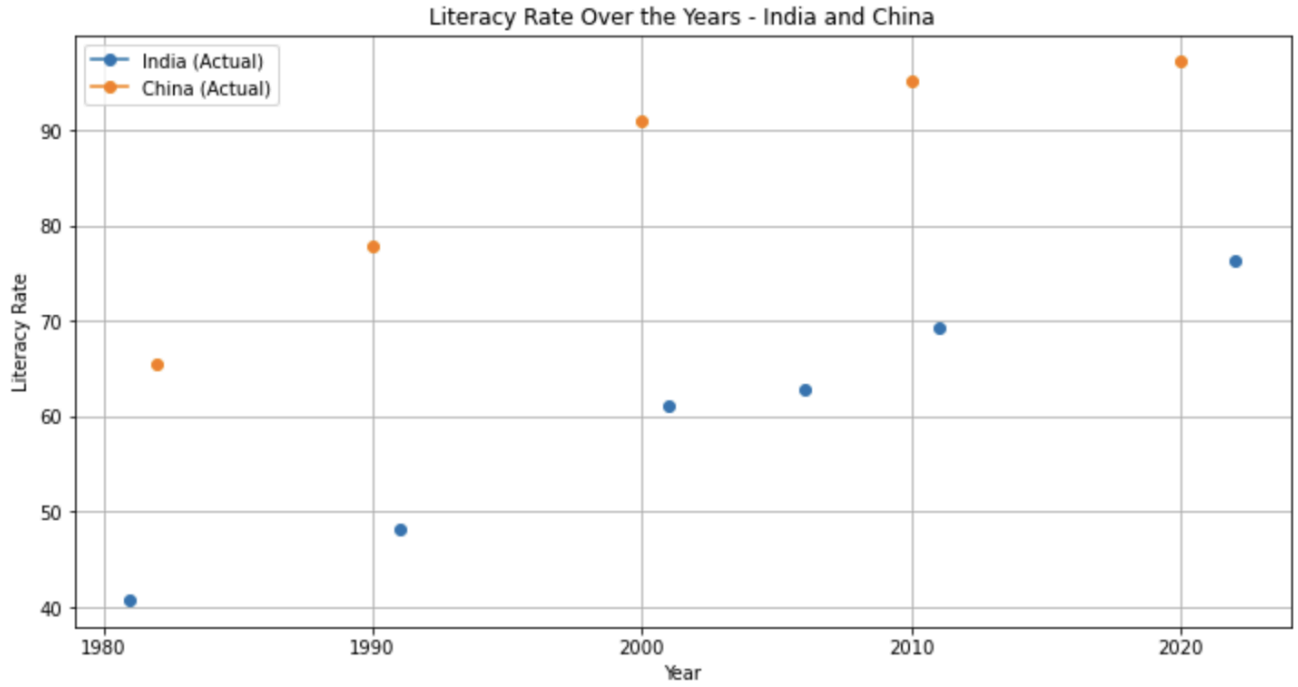
3) Literacy Rate Over the Years - Indian Subcontinent



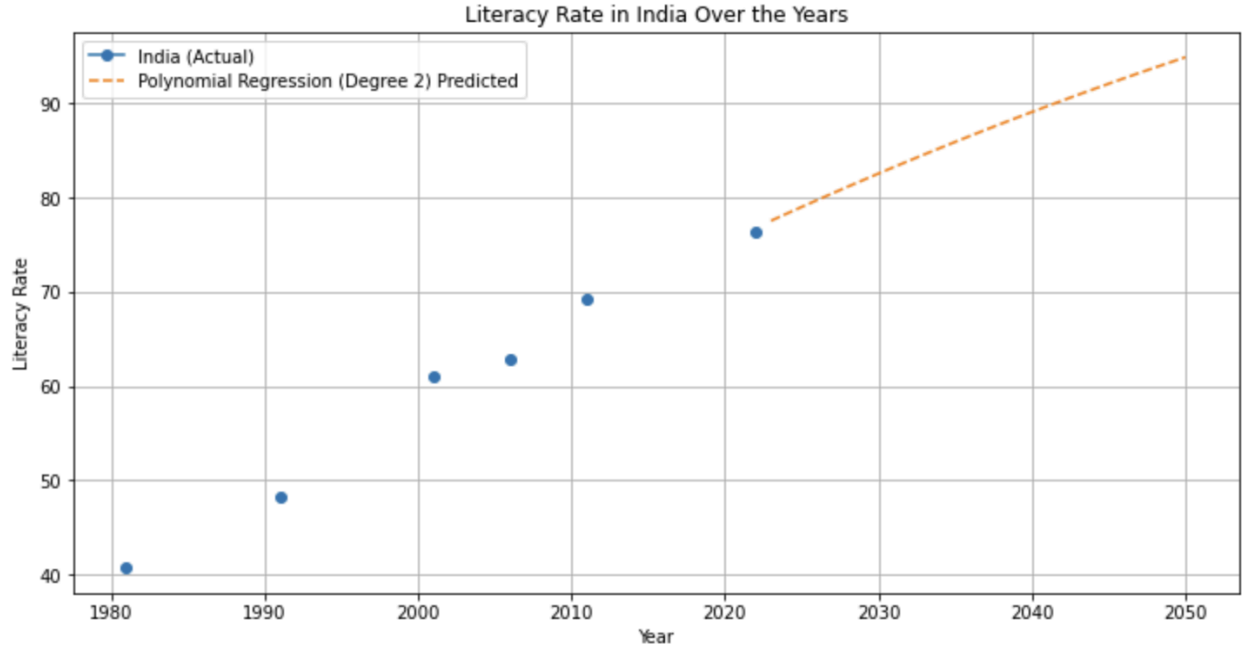
4) Literacy Rate Over the Years - Regions and Continents



5) Literacy Rate Over the Years - India and China



6) **Literacy Rate Prediction** and Actual Literacy Rate Over the Years - India

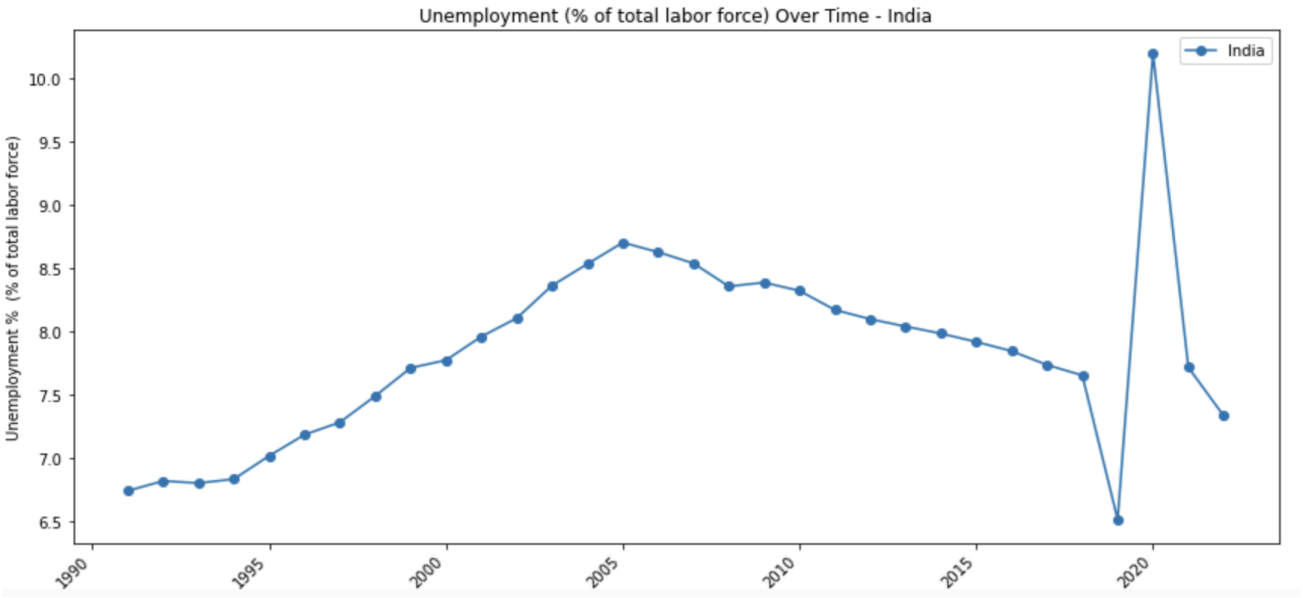


Predicted Literacy Rate for India (2023 to 2050):

Year 2023: 77.53321648696146
Year 2024: 78.27039361354218
Year 2025: 79.00029780004115
Year 2026: 79.7229290464602v
Year 2027: 80.43828735280294
Year 2028: 81.14637271906395
Year 2029: 81.84718514524138
Year 2030: 82.54072463134798
Year 2031: 83.22699117736556
Year 2032: 83.90598478330503
Year 2033: 84.57770544917003
Year 2034: 85.24215317494964
Year 2035: 85.89932796065114
Year 2036: 86.54922980627816
Year 2037: 87.1918587118198
Year 2038: 87.82721467728334
Year 2039: 88.45529770266876
Year 2040: 89.07610778797243
Year 2041: 89.689644933198
Year 2042: 90.29590913834181
Year 2043: 90.89490040340752
Year 2044: 91.48661872839148
Year 2045: 92.07106411329733
Year 2046: 92.64823655812143
Year 2047: 93.21813606287105
Year 2048: 93.7807626275353
Year 2049: 94.33611625212143
Year 2050: 94.88419693662945

<u>Unemployment, total (% of total labor force)</u> - Visualization and Prediction

1) Unemployment Over the Years - India



This graph depicts the unemployment rate in India as a percentage of the total labor force over time, spanning from 1990 to approximately 2022:

1990 - 2005: A steady climb in unemployment suggests economic challenges or increasing participation in the labor force without a commensurate number of jobs.

2005 - 2015: A period of decreasing unemployment rates, indicating improved job creation, possibly due to economic reforms, foreign investments, or other growth-stimulating factors.

2015 - 2020: A drastic spike in unemployment around 2020 is visible, likely reflecting the global economic disruption caused by the COVID-19 pandemic, which led to job losses across multiple sectors.

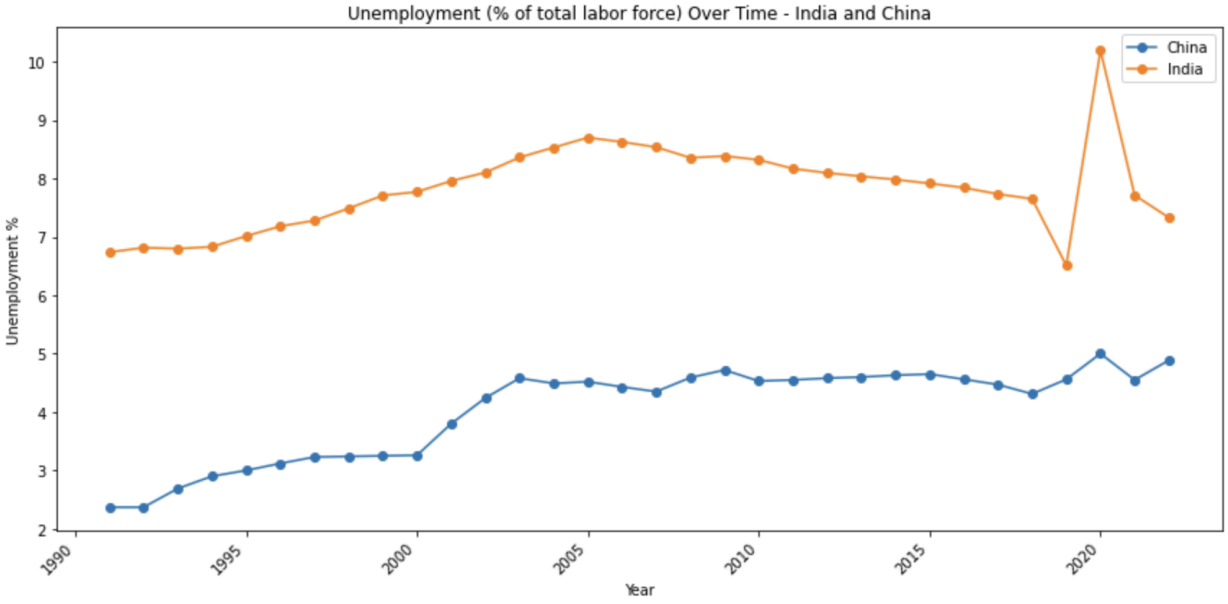
Post-2020: The graph shows a sharp decline in the unemployment rate after the peak, which might suggest a recovery phase, potentially supported by government relief

efforts, resumption of economic activities, or a shift in the job market towards new sectors.

2022: The unemployment rate in India as of the end of 2022 appears to have stabilized from the previous spike. While the exact rate is not visible, the downward trend suggests that the worst of the pandemic's impact may have passed, and the job market could be showing signs of recovery.

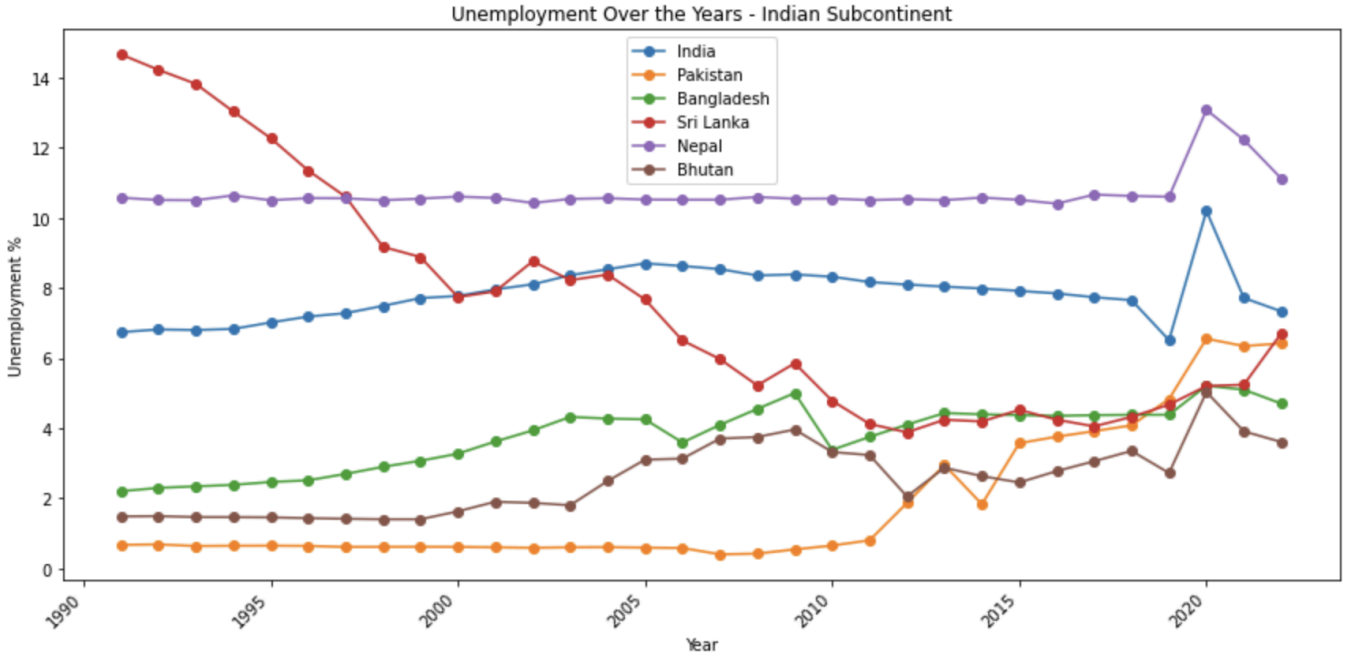
2) Unemployment Over the Years - India and Pakistan

3) Unemployment Over the Years - India and China

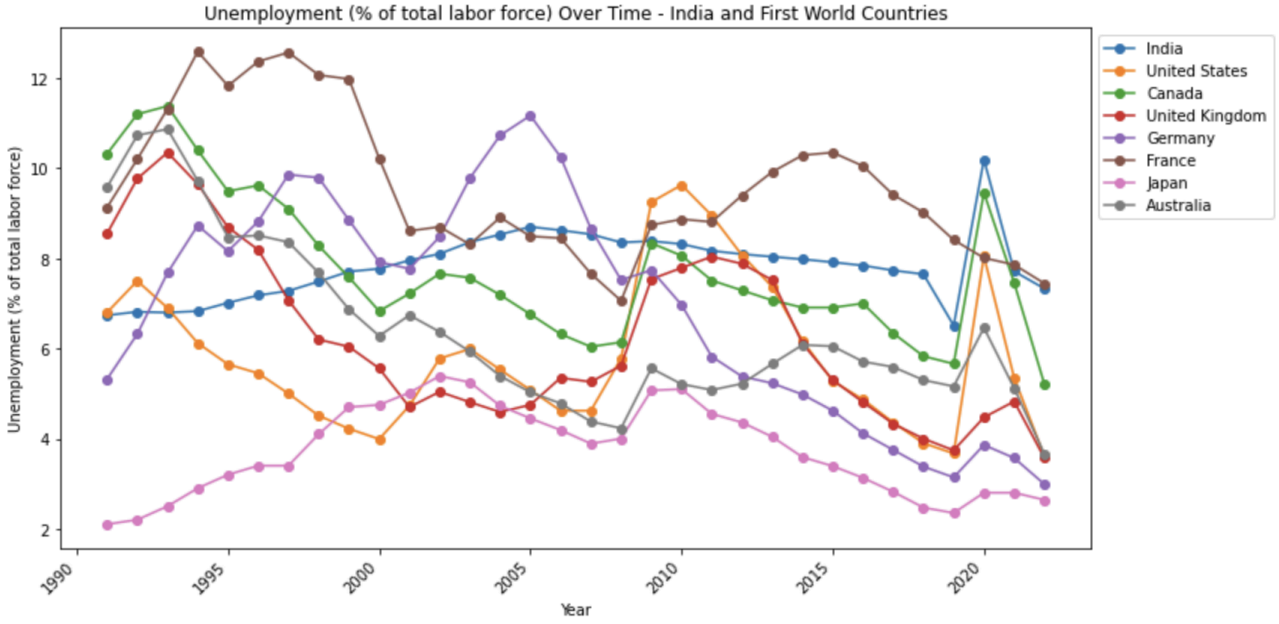


4) Unemployment Over the Years - India and the United States.

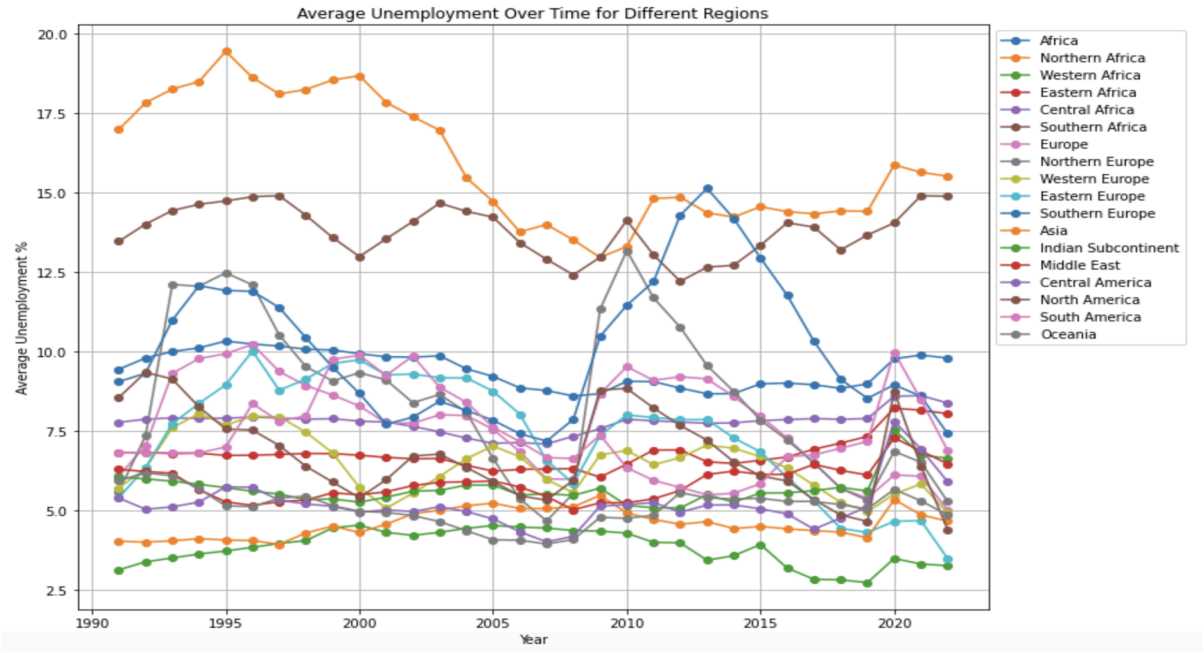
5) Unemployment Over the Years - Indian Subcontinent



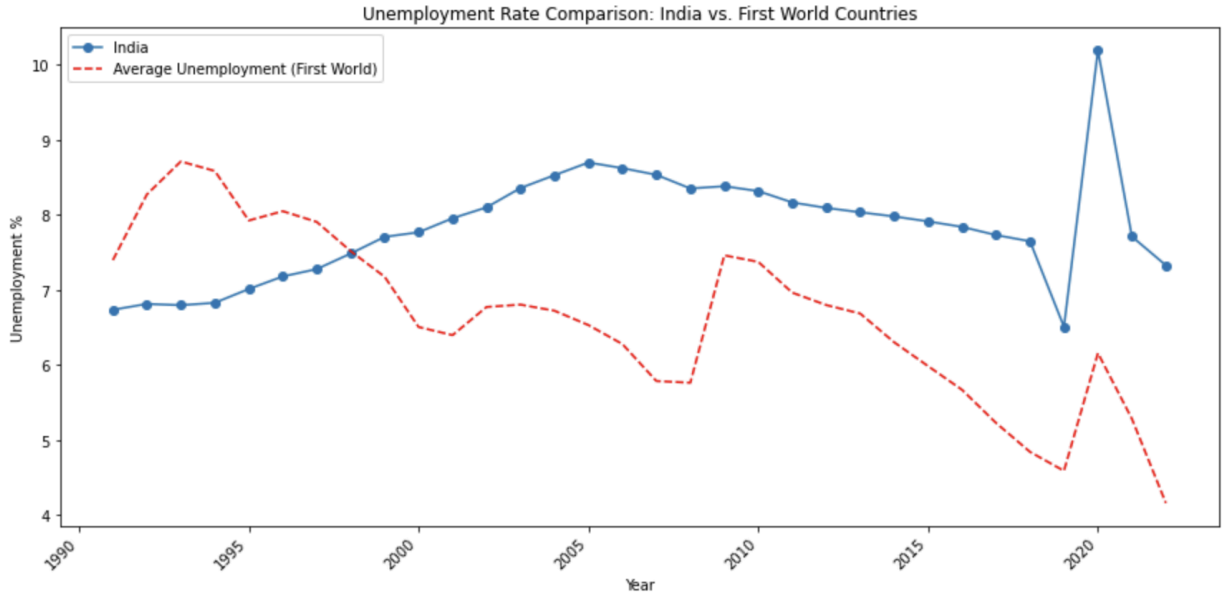
6) Unemployment Over the Years - India and First World Countries



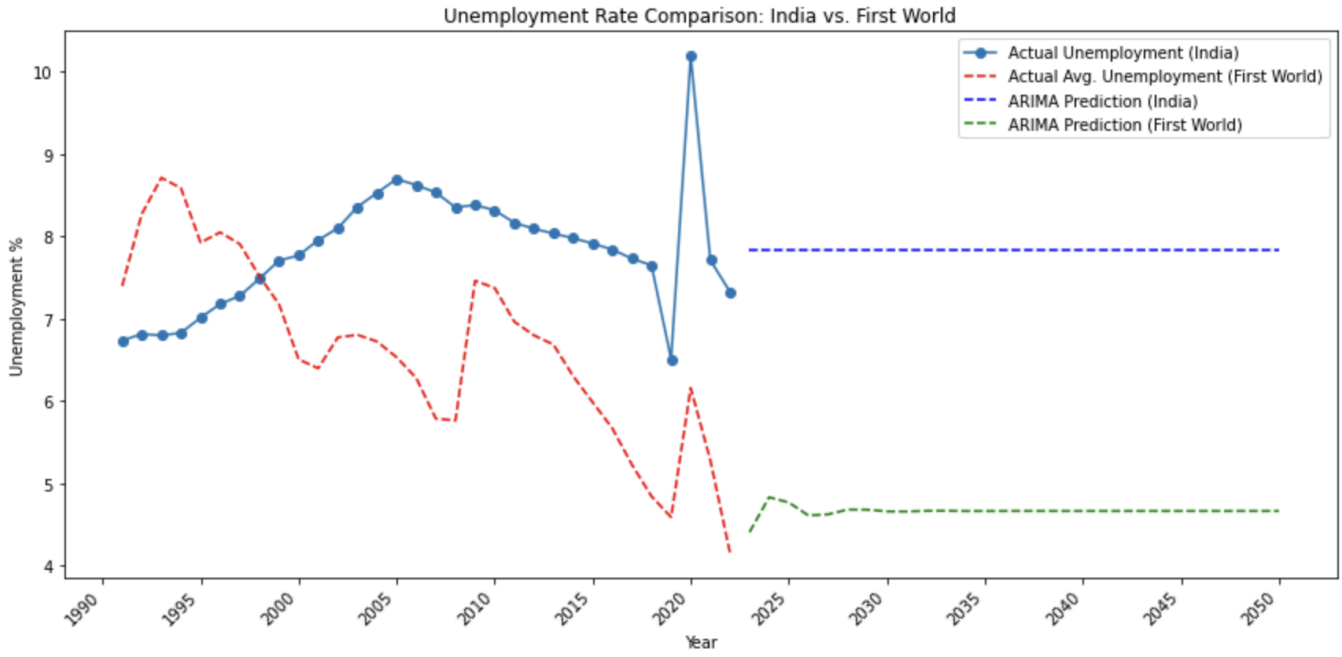
7) Unemployment Over the Years - Regions and Continents



8) Unemployment Over the Years - India and First World Countries



9) **Unemployment Prediction** and Actual Unemployment Over the Years - India and First World Countries

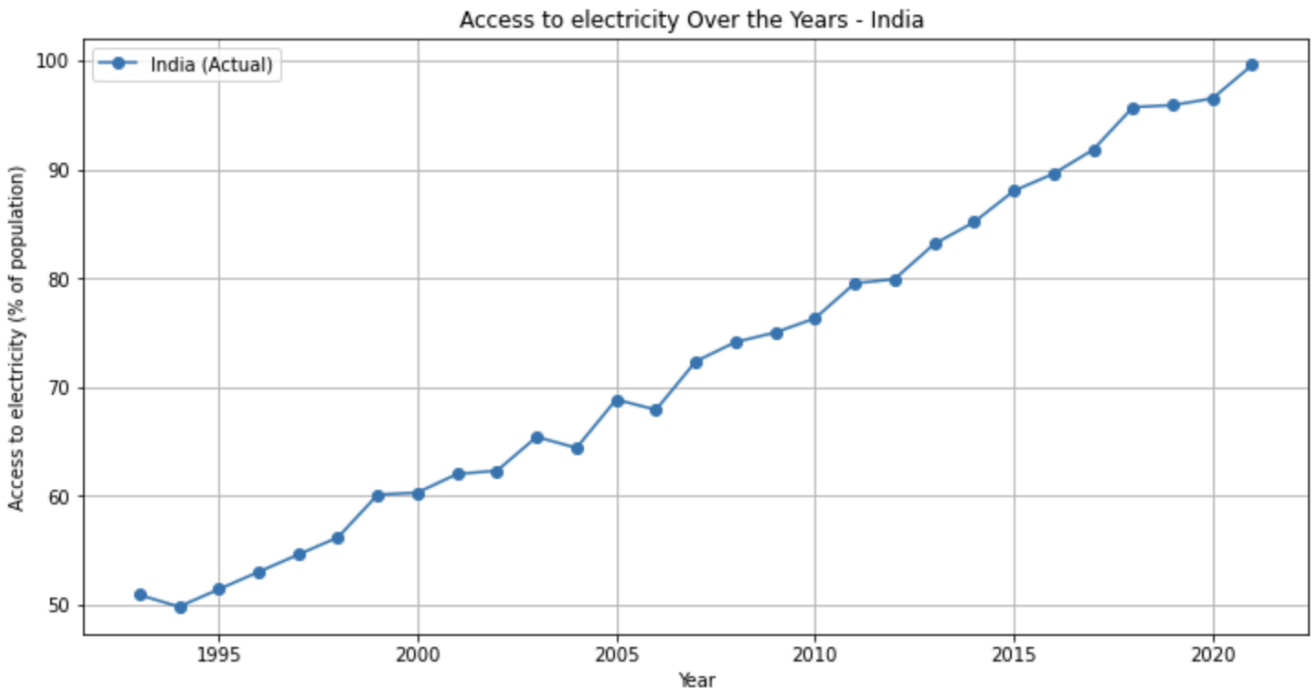


Predicted Unemployment, total (% of total labor force) for India (2023 to 2050):

[7.8330262 7.8330262 7.8330262 7.8330262 7.8330262 7.8330262 7.8330262
7.8330262 7.8330262 7.8330262 7.8330262 7.8330262 7.8330262 7.8330262
7.8330262 7.8330262 7.8330262 7.8330262 7.8330262 7.8330262 7.8330262
7.8330262 7.8330262 7.8330262 7.8330262 7.8330262 7.8330262 7.8330262
7.8330262]

<u>Access to Electricity (% of population)</u> - Visualization and Prediction

1) Access to Electricity Over the Years - India



The graph illustrates the progression of electricity access in India's population from the mid-1990s to 2022. Here is an analytical breakdown:

Initial Phase (Mid-1990s): The graph starts in the mid-1990s with less than 60% of India's population having access to electricity. This period marks the early stages of India's economic liberalization and indicates a significant portion of the population still lived without reliable electric power.

Gradual Improvement (Late 1990s - 2010): A consistent upward trend is evident, with access to electricity increasing steadily. The increase could be attributed to governmental efforts to expand infrastructure, rural electrification policies, and the growing Indian economy.

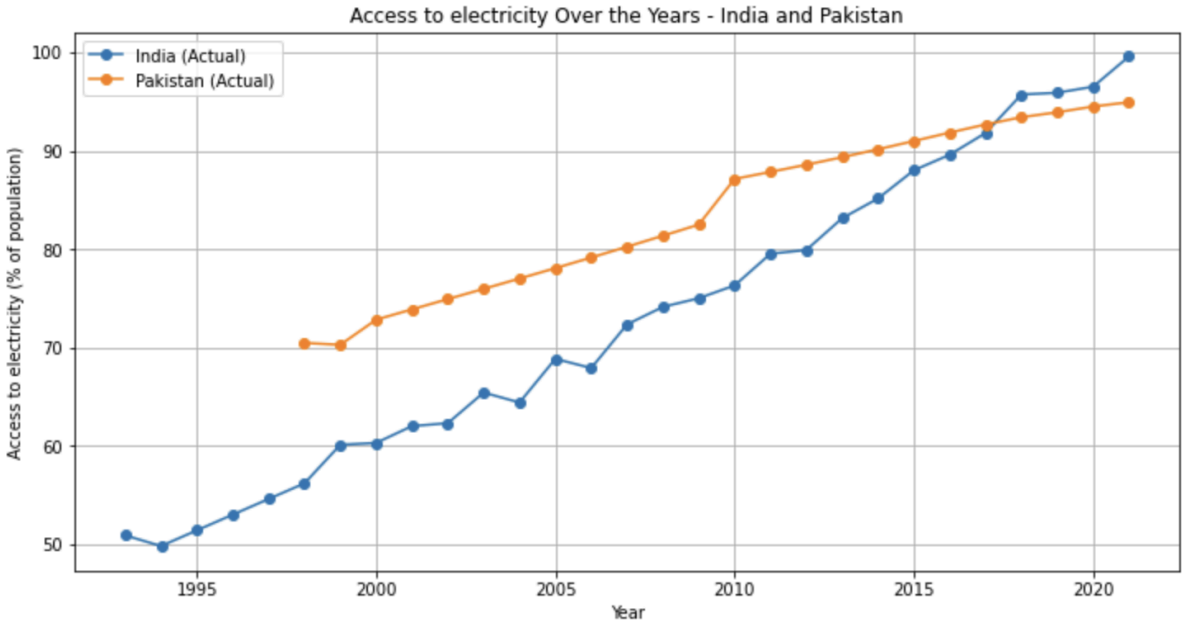
Accelerated Growth (2010 - 2015): There is a more pronounced increase in access to electricity during this period. This suggests intensified government initiatives, possibly

under programs like the Rajiv Gandhi Grameen Vidyutikaran Yojana (RGGVY) aimed at driving rural electrification.

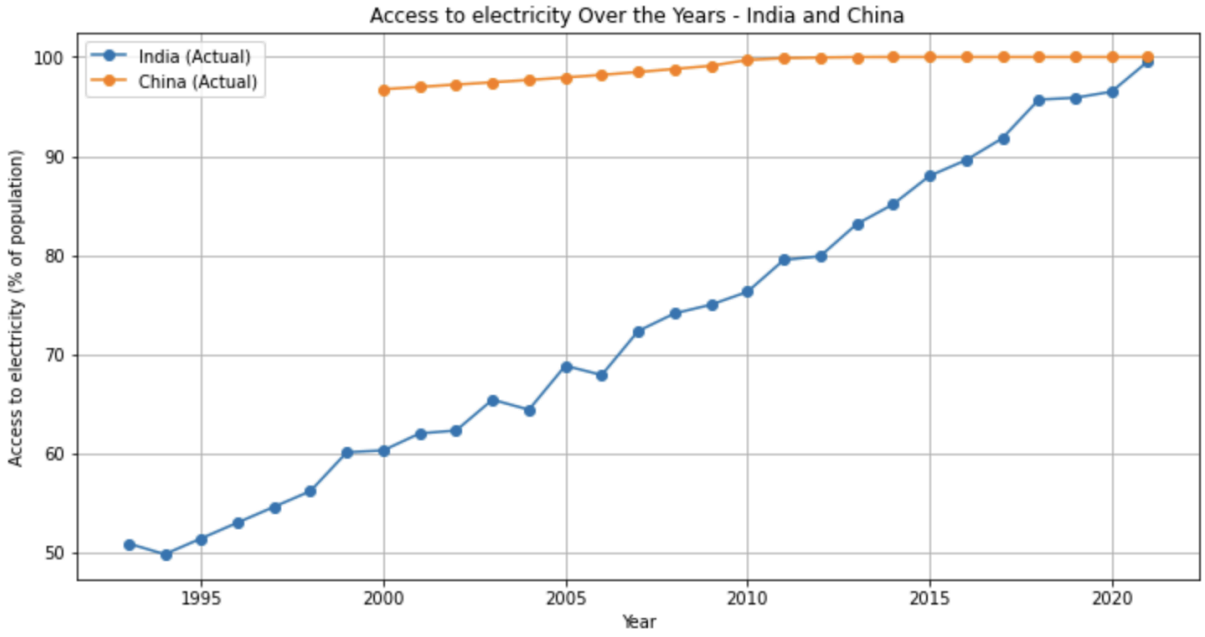
Plateauing Growth (2015 - Just Before 2020): As the access nears the 100% mark, the growth rate appears to slow down, indicating the approaching saturation of electricity access. The plateauing trend implies the challenge of reaching the last mile, where the remaining unelectrified populations are likely in remote or difficult-to-reach areas.

The graph provides a visual testament to India's commitment to enhancing the quality, albeit it doesn't capture the quality and reliability of the electricity supply, which are essential components of true energy access.

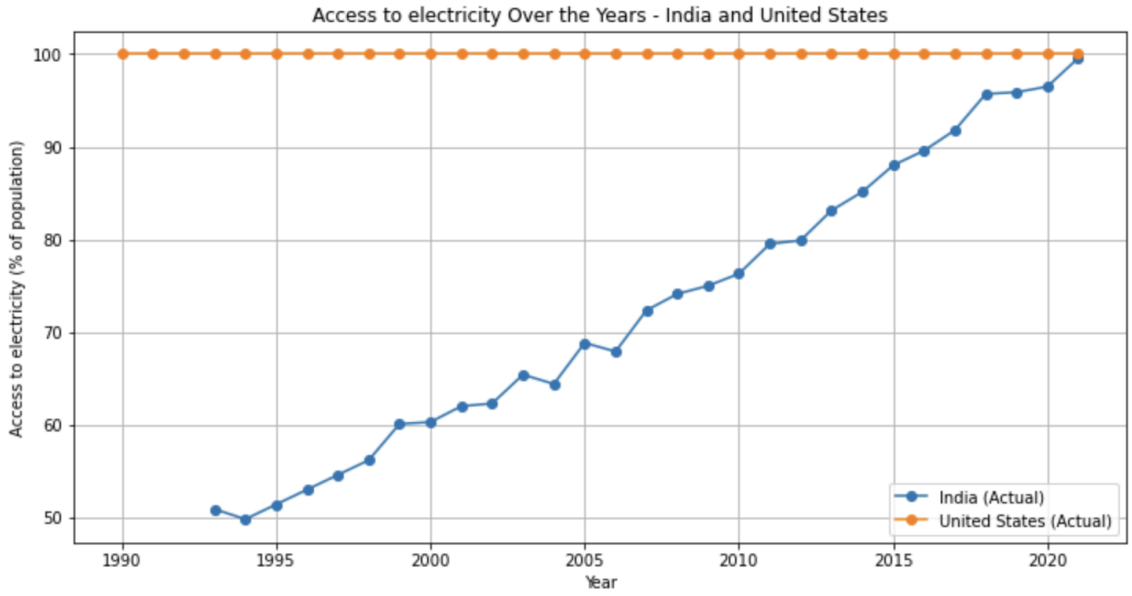
2) Access to Electricity Over the Years - India and Pakistan



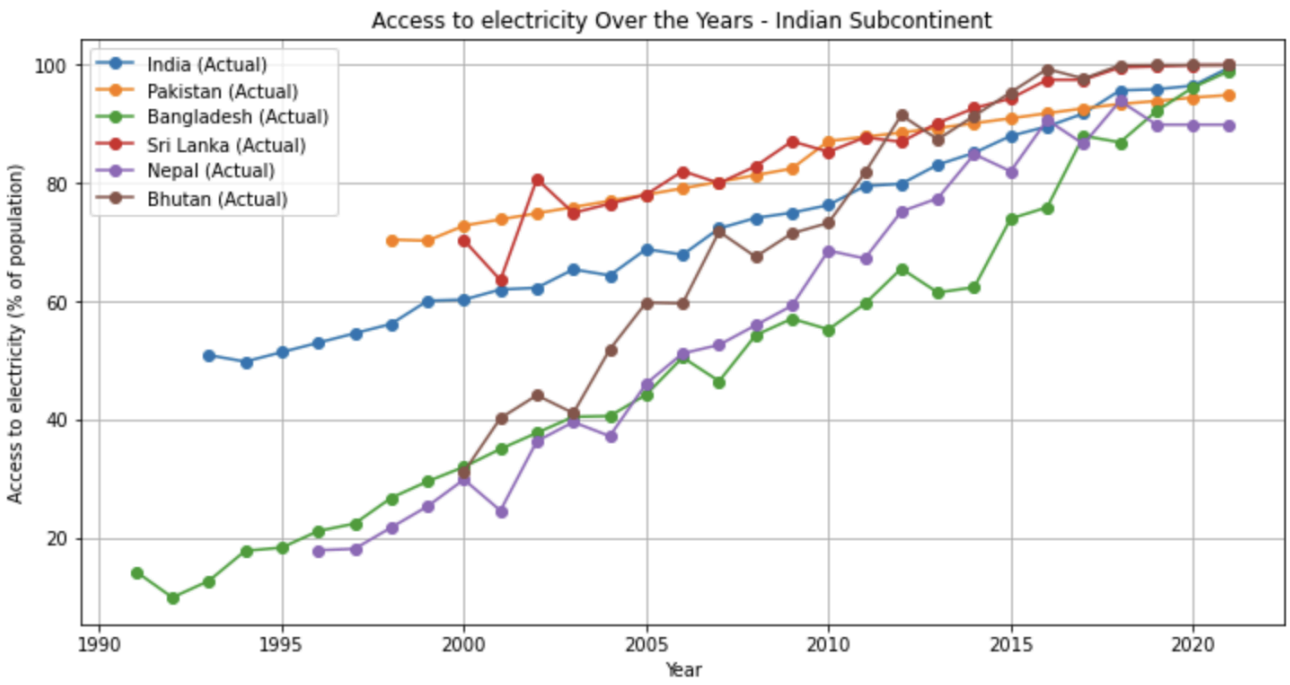
3) Access to Electricity Over the Years - India and China



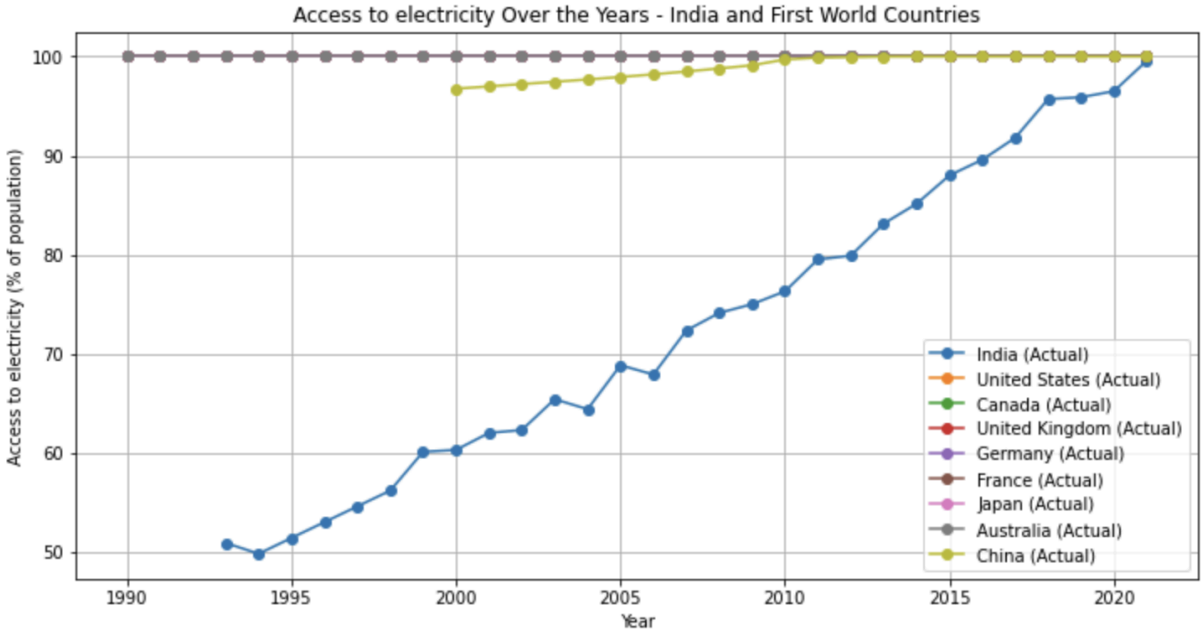
4) Access to electricity Over the Years - India and United States



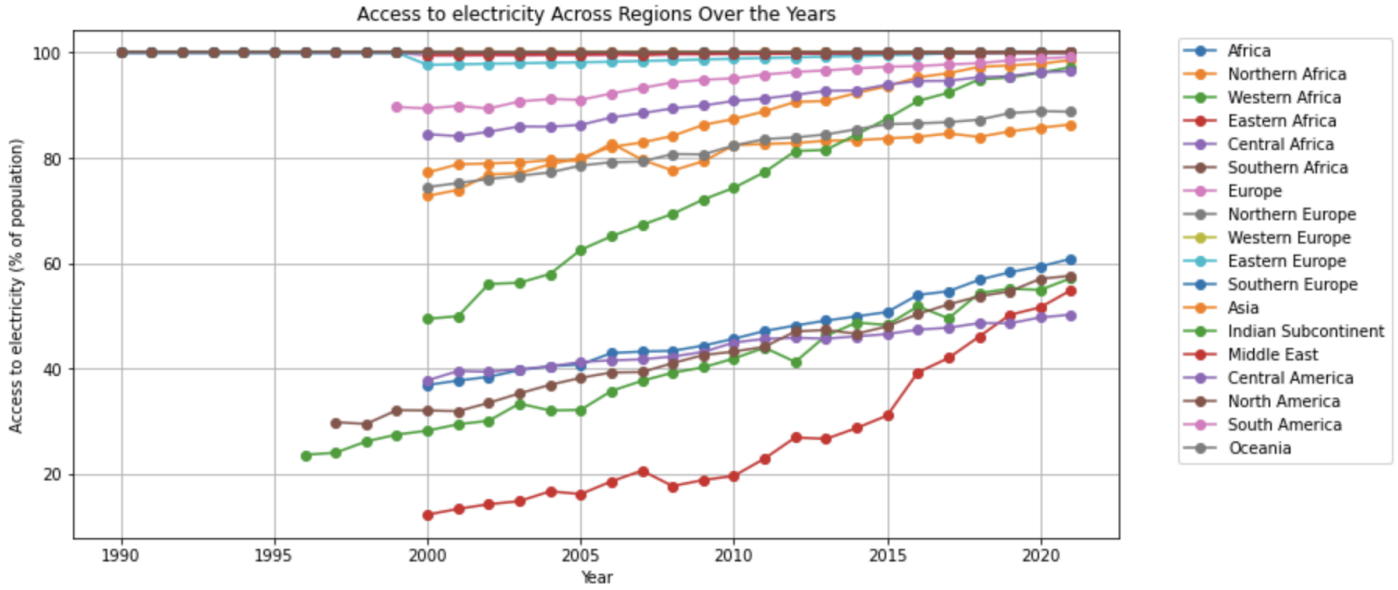
5) Access to electricity Over the Years - Indian Subcontinent



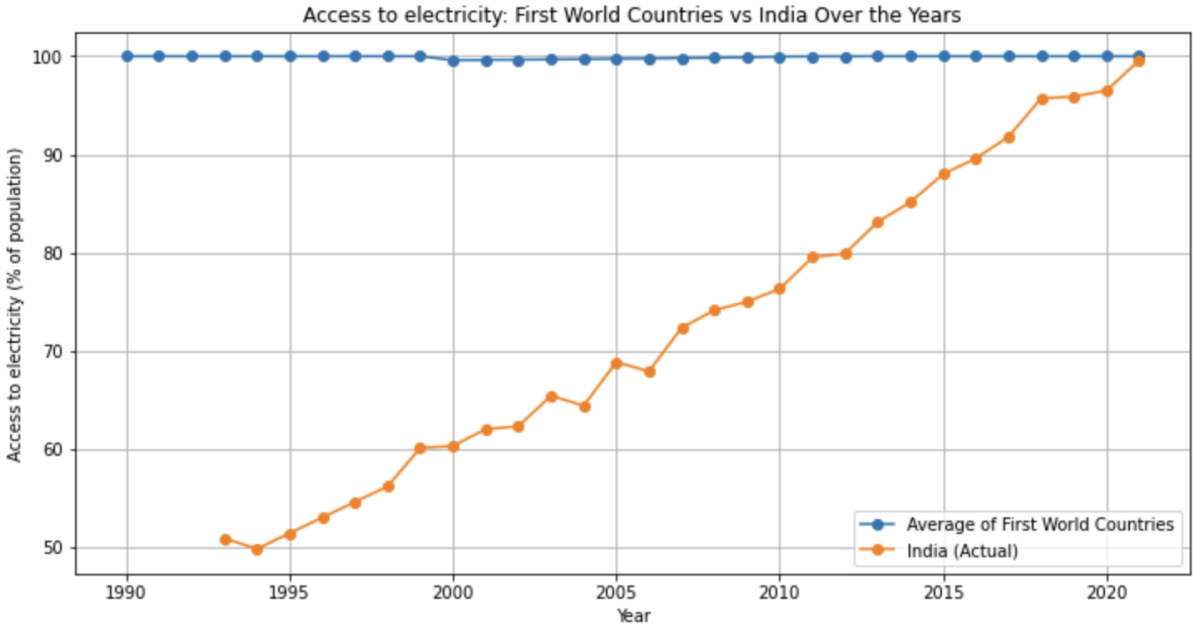
6) Access to electricity Over the Years - India and First World Countries



7) Access to electricity Over the Years - Regions and Continents



8) Access to electricity Over the Years - India and Average of First World Countries



Post-Forecast Clustering

India 2050 Forecasted Values

'GDP = 8.17988821e+12 ',

'GDP_Growth = 7.00295154',

'GDP_PerCap = 4693.283298',

'Employment_to_population = 48.33100929',

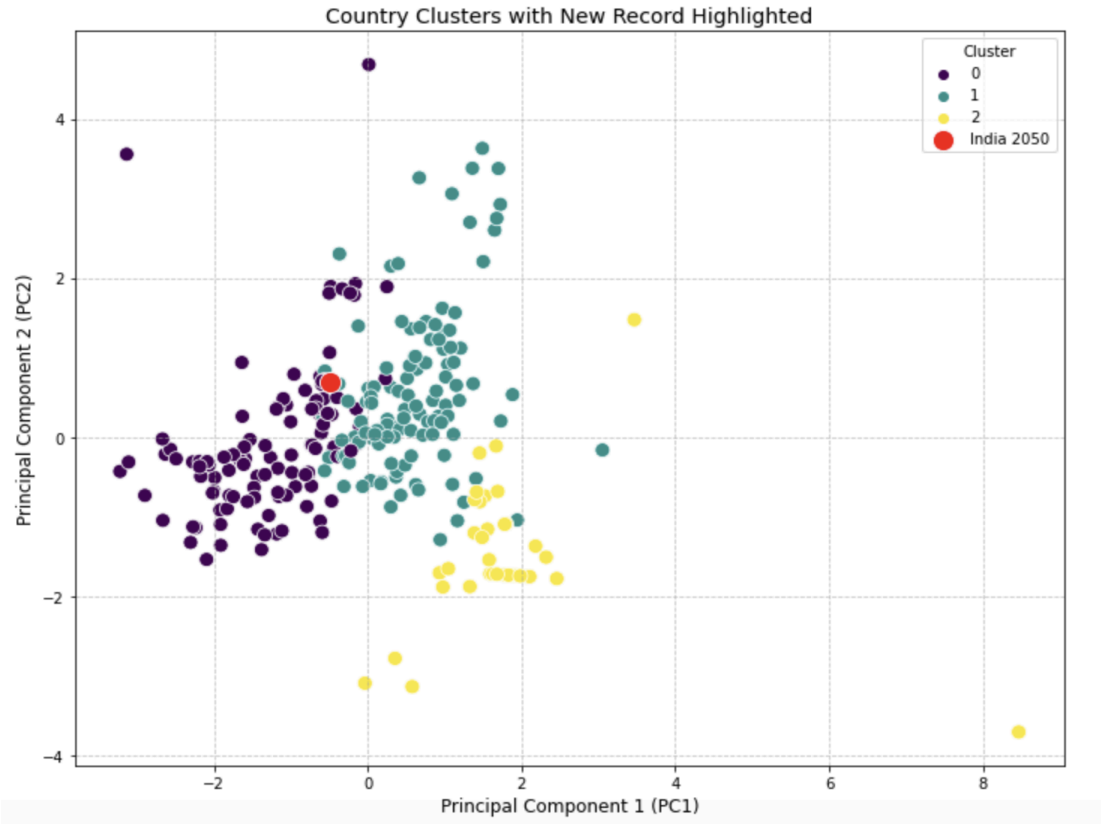
'Unemployment_total_% = 7.8330262',

'Literacy_Rate = 94.88419693662945',

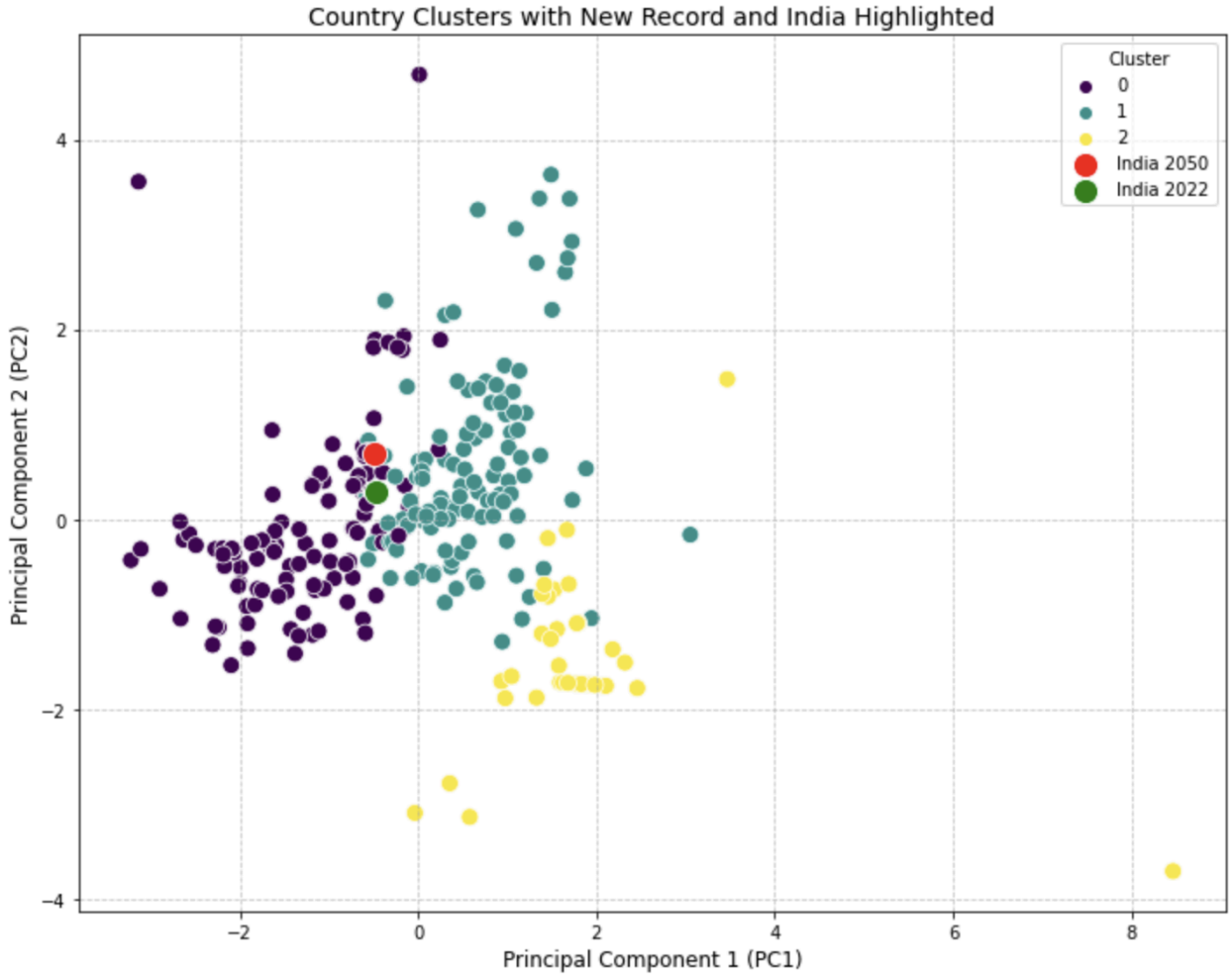
'Population_growth=0.2555841533350882',

'Access_to_electricity=100'

1) Clusters Formed After Plugging in the New Record



2) Formed Clusters with the 2022 values and 2050 values.



**** While Cluster 1 is designated as "First World Countries", Cluster 0 as “Third World Countries” and Cluster 2 as “Second World Countries”, this classification is anchored in the selected parameters. In reality, the true essence of "First World" involves socio-economic, political, and cultural considerations that extend beyond our current clustering criteria.**

**** A notable point to emphasize is that, while all countries traditionally deemed as "First World" find themselves in Cluster 1, not every country in Cluster 1 aligns precisely with this classification.**

India is found in “Cluster 0 “ yet again.

Conclusion and Inference

1) Until 2022 -

In summarizing India's multifaceted socio economic narrative up until 2022, the data from eight key indicators present a complex yet encouraging tableau of development. The steadfast climb in access to electricity symbolizes progress reaching the furthest corners of the nation, a testament to infrastructure achievements. Literacy rates, following a consistent upward trend, forecast a bright future for the youth. The economic landscape, as depicted by the undulating GDP growth rates, reflects resilience amidst global and domestic vicissitudes, with the overall GDP trajectory ascending sharply, underscoring India's expanding economic clout.

Concurrently, GDP per capita has burgeoned, indicating not just growth but a deepening of wealth among the populace. This is juxtaposed against the employment to population ratio's decline, signals shifting labor market dynamics and the urgency for job creation. India’s declining population growth rate does have potential to cause a demographic dividend if the declining growth rate leads to a larger proportion of the working-age population. However, it also presents challenges, such as the need for effective policy planning to manage aging populations in the future.

The unemployment rate narrative has its crests and troughs, climaxing in a dramatic spike around 2020 due to the pandemic's shockwaves, which disrupted industries and livelihoods but seems to be normalized in 2022 .

The conclusion of this multifaceted story in 2022 is not the end but a pivot to a new chapter. As India's economy shows signs of post-pandemic recuperation, the challenge lies in harmonizing economic vigor with sustainable employment opportunities, equitable wealth distribution, and educational growth. Ensuring that the progress, as seen in the electrification and literacy rates, translates into robust job markets and resilient economic structures will be pivotal. The data underscores a critical juncture where policy innovation, economic agility, and a commitment to inclusive growth will dictate India's trajectory in the years to come.

2) INDIA 2050 -

The clustering of India's socioeconomic data points for 2022 and the forecast for 2050 into the same cluster (Cluster 0) suggests that the underlying patterns in the data used for clustering have not significantly changed from the present to the forecast. This could mean that despite changes and growth projected or already occurring in the socioeconomic indicators, the relative positioning of India in comparison to other countries in the dataset remains similar. The clustering algorithm considers the multidimensional data and places India in a group with countries that have analogous characteristics.

This consistency might indicate that the forecast anticipates growth and improvements along the same trajectory as current trends. It also implies that the factors defining the clusters are robust enough that even with India's socioeconomic changes, its fundamental characteristics in relation to other countries in the same cluster remain consistent. This cannot be a positive sign if Cluster 0 represents a group of countries that do not have positive attributes such as strong economies, good healthcare systems, or high education levels.

This outcome underscores the limitations of the current clustering approach, which is based on a selected set of economic and developmental parameters. True development is multidimensional. For a richer, more accurate representation, future analyses should incorporate diverse indicators, these additional parameters would allow for a clustering that captures the complex, dynamic nature of global development more faithfully. The current clustering reflects just a snapshot based on a specific set of parameters and may not fully encapsulate the multifaceted nature of development.

A truly comprehensive analysis requires a broader set of indicators. Health metrics, educational quality, environmental sustainability, and social equity are critical facets that paint a more complete picture of a country's progression. The absence of these factors due to time or computational constraints leaves a gap in the narrative, potentially overlooking areas where significant developments—or lack thereof—might have occurred.

Future analyses should strive to encompass more granular health data and additionally, employ advanced analytical techniques that can reveal complex interdependencies and patterns not evident through simpler models.

In conclusion, while the current clustering provides a valuable perspective on India's development, it inherently lacks the depth to account for all dimensions of progress. Expanding the scope of future analyses will be vital for crafting a nuanced understanding of development that aligns more closely with real-world complexities, thereby enabling more informed and strategic decision-making for long-term growth and equity.