ESG Analysis and Its Relevance to ESG Goals and DEIB

Computational Data Analytics with Python

Angel E. Lanto
Master's in Business Analytics

Table Of Contents

I. Overview of the ESG Issue: Access to clean cooking (SDG7: Data and Projections)

In 2023, more than 2 billion people are still reliant on traditional cooking fuels, which not only contribute to environmental degradation but also pose severe health risks. The connection between household air pollution and premature deaths is alarming. Despite progress in some areas, the covid-19 pandemic and its aftermath have exacerbated the situation, making it harder for low-income communities to maintain access to cleaner alternatives (www.iea.org).

This challenge is multifaceted, involving both energy and health sectors, and addressing it requires innovative solutions, including improved infrastructure, affordable clean energy technologies, and targeted policies to reduce the financial burden on vulnerable populations. Solutions could involve the scaling of more sustainable cooking technologies, like clean stoves, solar cookers, or biogas systems, but affordability and accessibility remain significant barriers.

Source: https://www.iea.org/reports/a-vision-for-clean-cooking-access-for-all

In line with this, this report aims to relate the analysis of clean cooking access to ESG goals, focusing on social impact and sustainable energy solutions. Additionally, it aims to address ethical considerations by evaluating the fairness, inclusivity, and bias in the data, and proposing improvements for more realistic and representative conclusions. With the help of ChatGPT (2025), the proponent successfully executed the visualizations and analysis, providing valuable insights for decision-making and intervention strategies.

II. Data Preparation

a. Data Overview

The dataset provided valuable insights for analyzing global trends over time. It contains information on access to clean cooking fuels and technologies across various countries. Each row represents a country, and the columns include the country name, country code, series name, and series code. The dataset spans multiple years (2000–2021), with each year representing the percentage of the population in that country with access to clean cooking fuels and technologies.

ESG-Data.csv

In summary, this dataset tracks the global progress in improving access to clean cooking solutions, which is relevant to understanding energy access, health risks, and the environmental impact of traditional cooking fuels. The time-series nature of the data allows for analyzing trends in clean cooking access over time across different countries.

b. Data Cleaning and Transformation

LANTO_A3-Individu
al-Assignment.ipynb

To ensure the data was suitable for analysis, I first loaded it from a CSV file and replaced placeholder values (..) with NaN to handle missing data. The year columns were converted to numeric types to facilitate time-series analysis. I also removed unnecessary columns and rows with missing country information to streamline the dataset.

Next, I reshaped the DataFrame by melting it from a wide format (with separate columns for each year) into a long format. This transformation resulted in two columns: "Year," which contains the year values, and "Value," which holds the corresponding data for each country and year. This restructuring simplifies the data, making it more suitable for time-series analysis and further processing.

III. Exploratory Data Analysis (EDA)

a. Basic Visualization

The analysis of the ESG data covers multiple aspects, including the distribution of values, correlations over time, and trends in global access to clean cooking fuels and technologies. The findings shed light on both global progress and disparities across different nations in meeting ESG objectives, particularly concerning clean energy access, environmental impact, and social well-being.

Please note that there are no data labels on the picture below. However, it is recommended to explore the values interactively within the notebook, as the visualizations were created using the Plotly library, which offers interactive features such as zooming, hovering for details, and dynamic updates. This allows for a more in-depth and flexible analysis of the data.

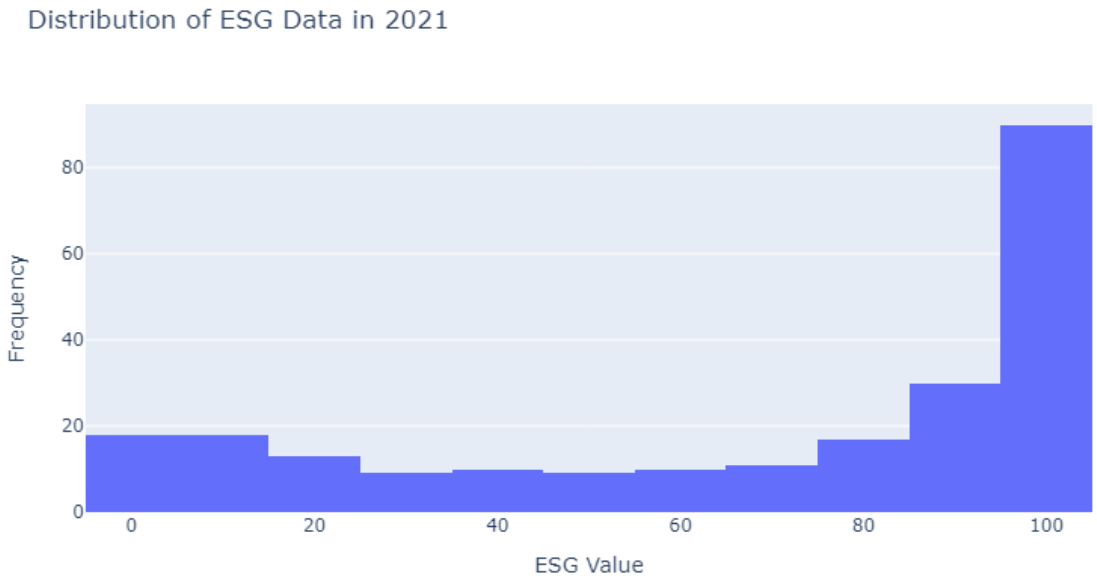

Figure 1. Distribution of ESG Data in 2021

The histogram shows a skewed distribution in ESG values for 2021, with the majority of countries having values close to 100. A smaller number of countries exhibit lower ESG values, indicating a significant disparity in access to clean cooking technologies and related social and environmental factors globally.

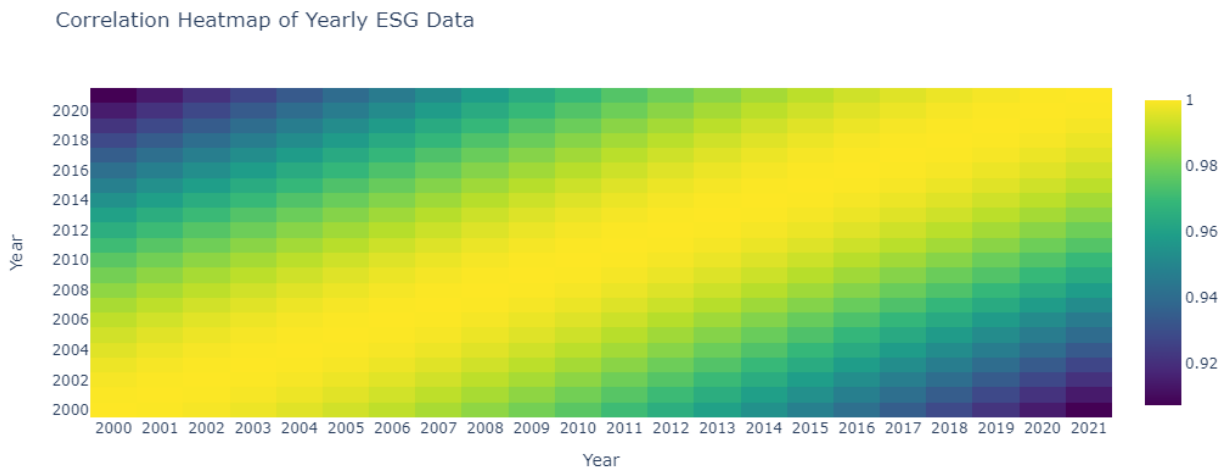

Figure 2. Correlation Heatmap of Yearly ESG Data

The heatmap reveals a strong positive correlation between ESG values across consecutive years, with values close to 1 for most years. This suggests that countries showing higher ESG scores in one year tend to maintain or improve their scores in subsequent years, indicating consistent progress in sustainable practices and policies.

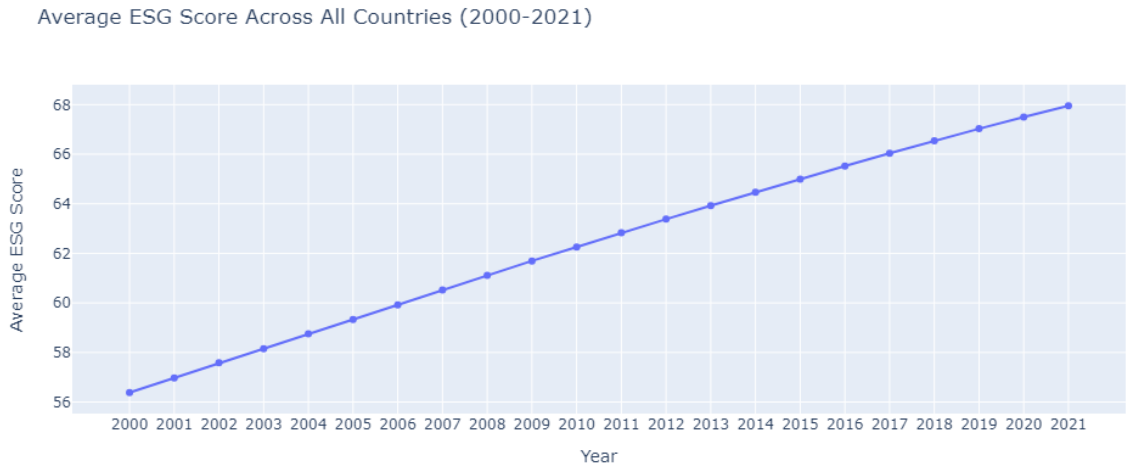

Figure 3. Average ESG Score Across All Countries (2000-2021)

The line chart indicates a steady increase in the average ESG score across all countries from 2000 to 2021. This positive trend reflects global improvements in access to clean cooking solutions, renewable energy, and other sustainable practices, aligning with broader ESG goals. According to Asteriou, Pilbeam, Litsios, and Pouliot (2024), countries with improved ESG scores from 2000 to 2021 have delivered the best returns for international investors, mainly driven by higher economic growth rates, and are largely ESG-low countries.

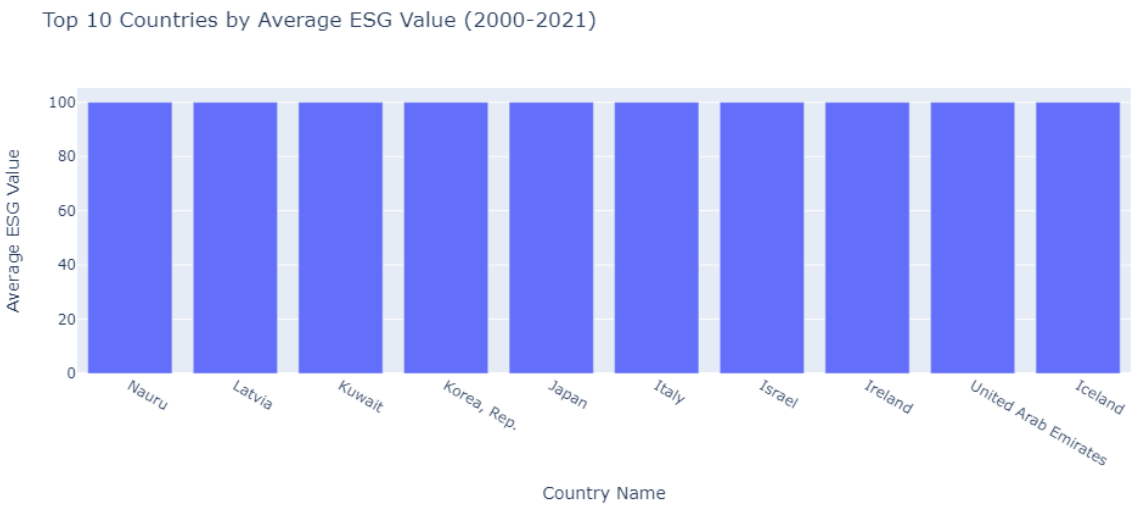

Figure 4. Top 10 Countries by Average ESG Value (2000-2021)

The bar chart highlights the countries with the highest average ESG values, including Nauru, Latvia, and Kuwait. These countries consistently score high, suggesting effective policies and practices in clean energy access and environmental sustainability.

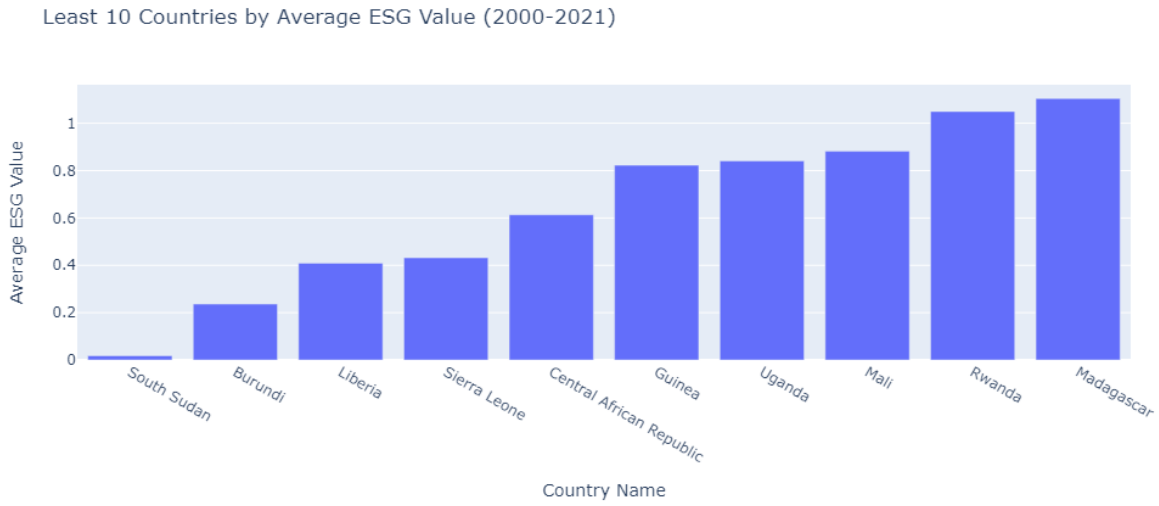

Figure 5. Least 10 Countries by Average ESG Value (2000-2021)

In contrast, the least 10 countries, such as South Sudan and Burundi, show significantly lower ESG scores. These countries face considerable challenges in achieving access to clean energy and other ESG objectives, highlighting areas where further interventions and support are needed.

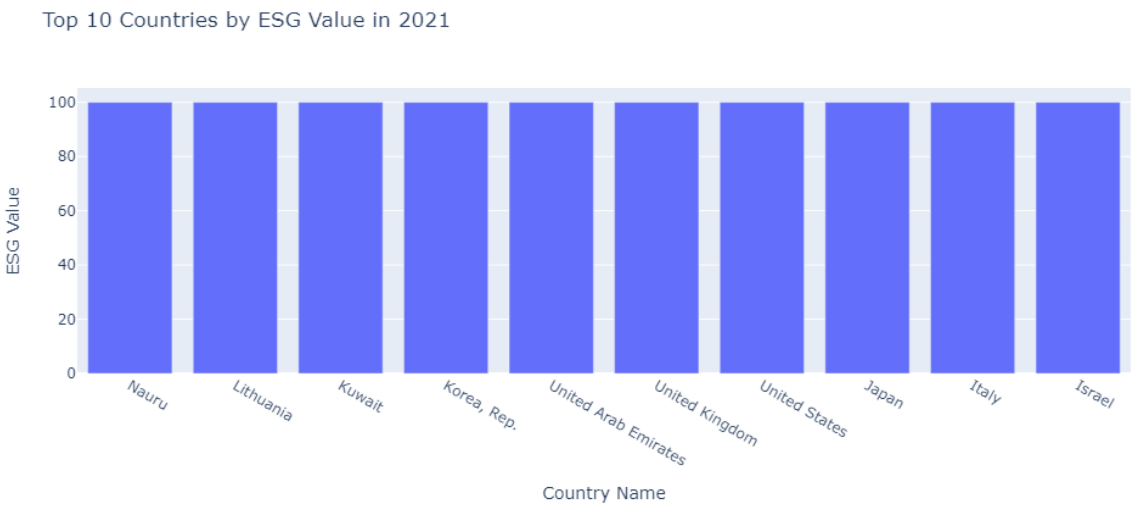

Figure 6. Top 10 Countries by ESG Value in 2021

The bar chart for 2021 highlights the countries with the highest ESG values, showing a similar trend to the previous chart but focused on a specific year. Countries like Nauru and Lithuania continue to lead in sustainable practices and clean energy access.

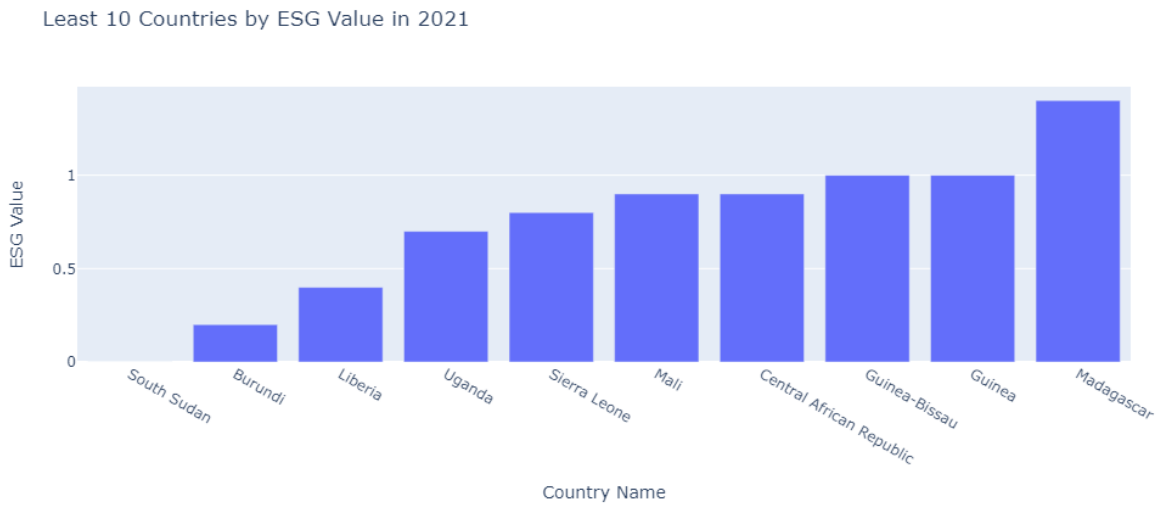

Figure 7. Least 10 Countries by ESG Value in 2021

The chart reveals the countries with the lowest ESG scores in 2021, underscoring the urgent need for focused efforts to improve energy access, reduce environmental degradation, and address social inequalities.

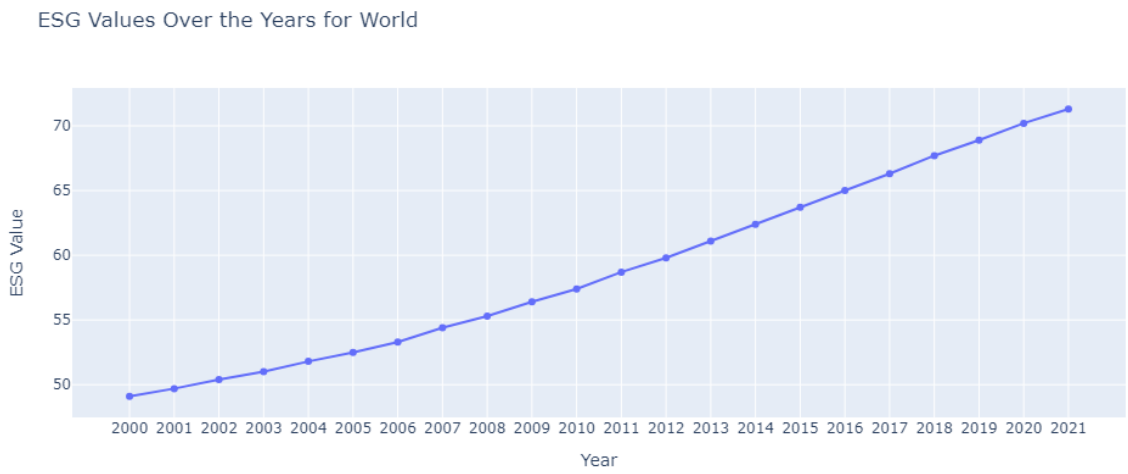

Figure 8. ESG Values Over the Years for Chosen Country: World

This line chart shows the global trend of increasing ESG values from 2000 to 2021. The steady rise represents positive global progress toward sustainable development, driven by international efforts to combat climate change and improve public health.

Figure 9. ESG Values Over the Years for Chosen Country: Philippines

The Philippines' ESG scores have also shown a steady increase over the years, reflecting progress in energy access and environmental policies, although it remains below the global average.

Overall, these results and interpretations underline the global progress toward meeting ESG objectives while also highlighting the areas that require more attention and investment, particularly in countries with lower ESG scores. The analysis contributes valuable insights into how different regions are advancing in their sustainable development efforts and the challenges they continue to face.

b. Modelling

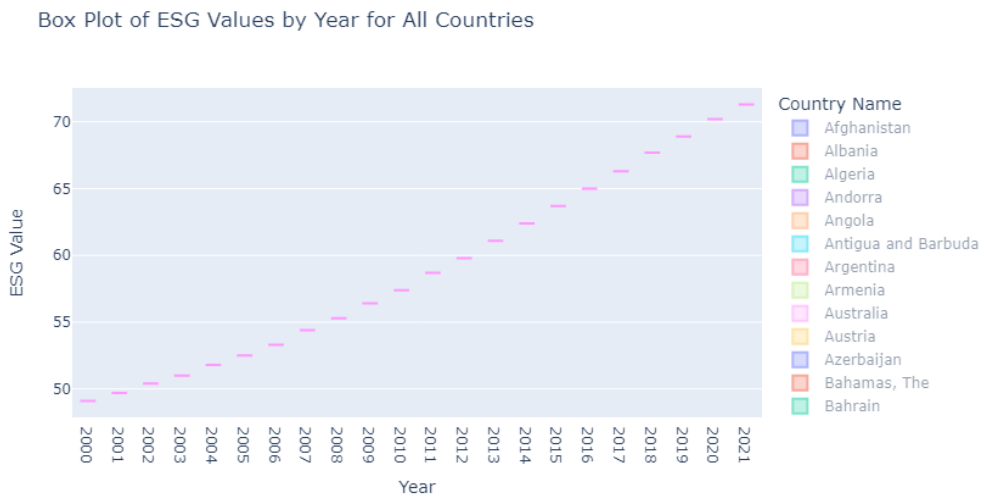

Figure 10. Box Plot of ESG Values by Year for World

The box plot demonstrates the distribution of ESG values across all countries over the years. This figure allows us to choose different countries in the filter section at the side. It shows a clear upward global trend in the median ESG values from 2000 to 2021, with less variability in the most recent years. This indicates that while some countries have made significant improvements in achieving ESG goals, most countries are progressing steadily toward higher ESG values.

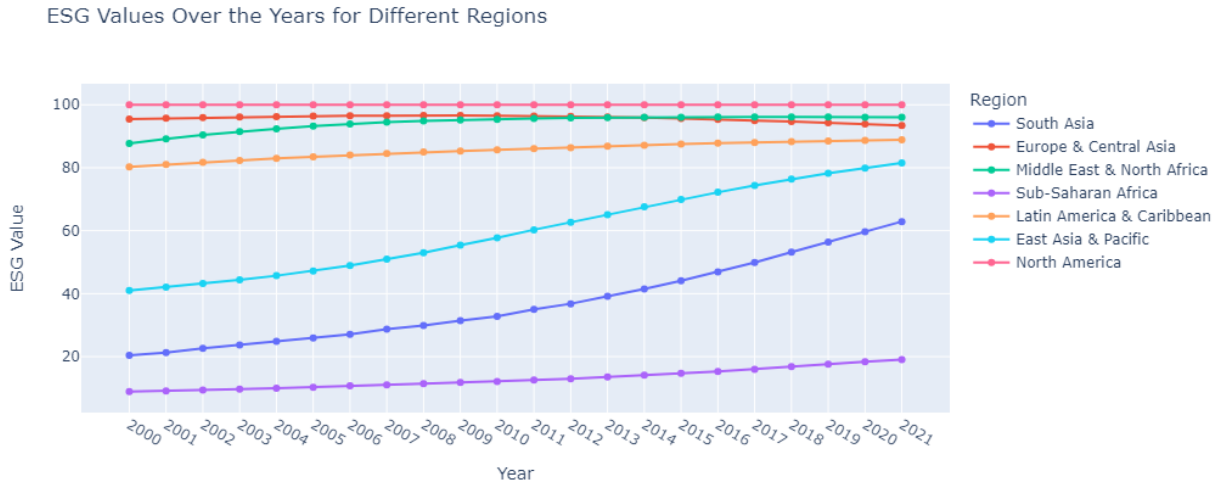

Figure 11. ESG Values Over the Years for Different Regions

The line chart shows the ESG values over time for various regions. North America, East Asia & Pacific, and Latin America & the Caribbean consistently perform well with higher ESG values, while regions such as South Asia, Sub-Saharan Africa, and the Middle East & North Africa are lagging, reflecting disparities in achieving sustainable development goals. These trends highlight the regional inequalities in addressing environmental and social challenges.

Figure 12. ESG Values Over the Years for Different Income Groups

The chart presents the ESG values for different income groups over the years. High-income countries lead in ESG performance, followed by upper-middle-income countries. Low-income countries show the slowest progress, with ESG values remaining comparatively low throughout the period. This highlights the significant relationship between income level and the ability to achieve high ESG standards, suggesting that wealthier countries have more resources to invest in sustainable technologies and practices.

These findings underscore the global disparities in ESG performance, with high-income regions and countries showing consistent progress, while low-income regions face challenges in advancing ESG objectives. The data also highlights the importance of focusing on underperforming regions and income groups to ensure more equitable progress in achieving global sustainability goals.

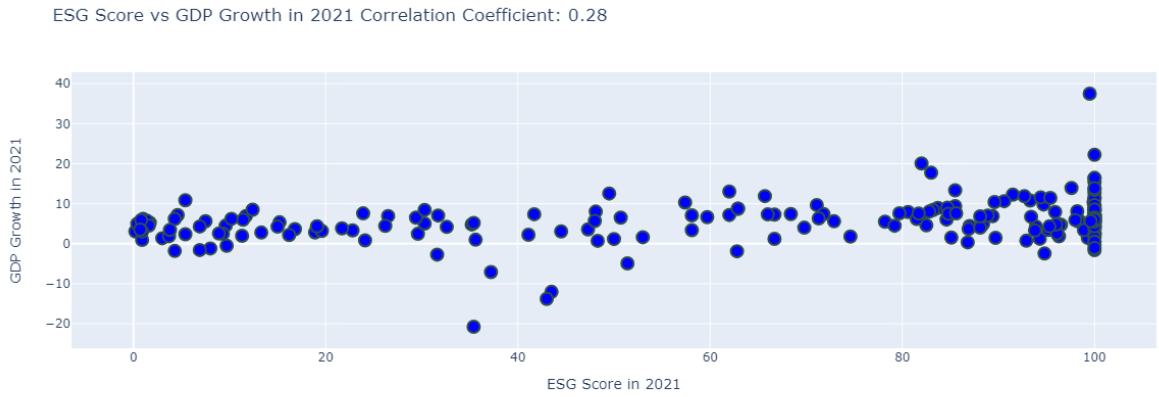

Figure 13. Correlation between ESG Score and GDP Growth in 2021

The scatter plot shows a weak positive correlation (0.28) between ESG scores and GDP growth in 2021. While there is a slight tendency for higher ESG scores to correlate with

higher GDP growth, the relationship is weak and not consistent. Most data points are clustered around lower GDP growth values, with a few outliers showing extreme values. The regression line does not reveal a strong upward or downward trend, confirming the weak correlation. Other factors likely influence GDP growth more significantly than ESG scores.

c. Data Analytics Technique: ARIMA Time Series Forecasting

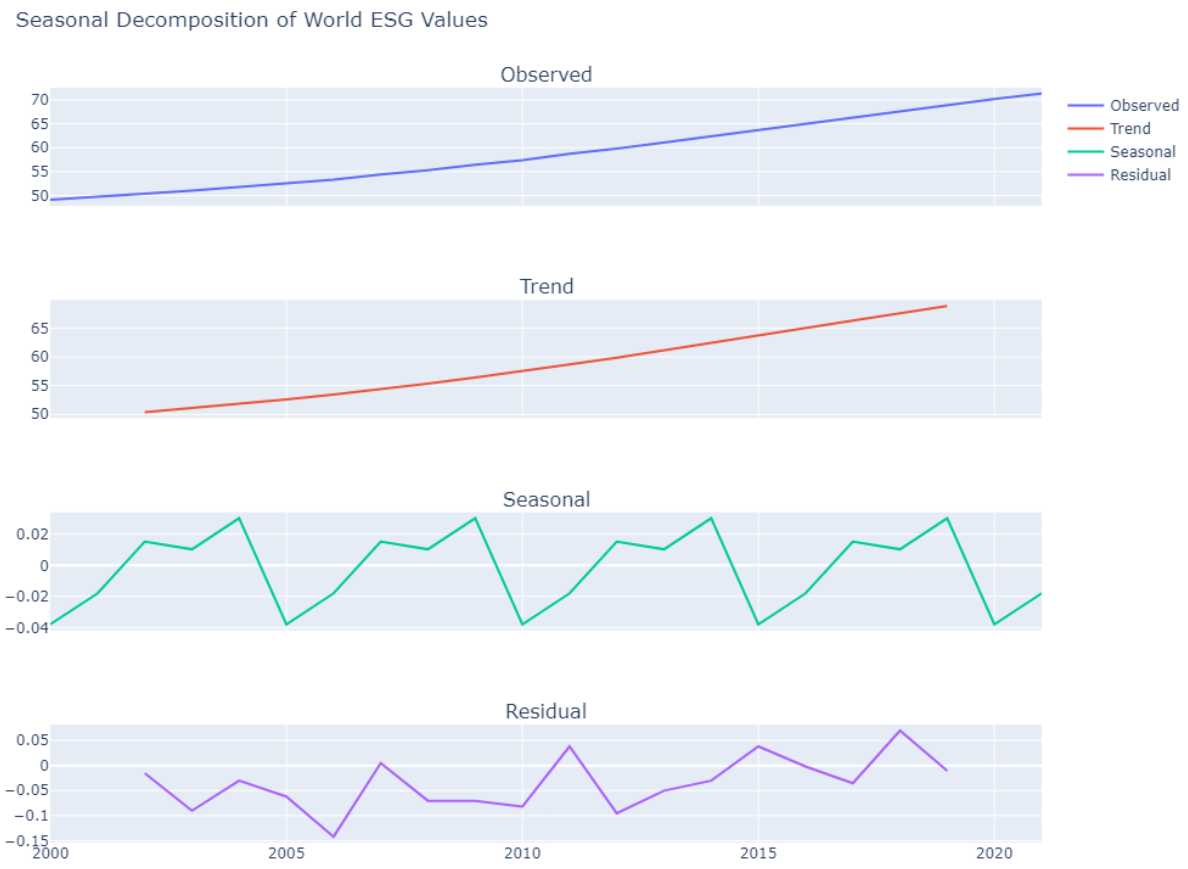

Figure 10. Seasonal Decomposition of World ESG Values

The seasonal decomposition of the world ESG values reveals three components: observed values, trend, and residuals. The observed plot shows a steady increase in ESG values from 2000 to 2021. The trend component further confirms this gradual upward movement, indicating that global ESG values have been improving over the years. The seasonal component highlights periodic fluctuations in ESG values, while the residuals component shows the deviations from the expected values, which appear random with no clear pattern.

Stationarity Test (ADF Statistic)
The Augmented Dickey-Fuller (ADF) test results indicate an ADF Statistic of -6.843818 and a p-value of 0.000000. Since the p-value is less than 0.05, we reject the null hypothesis that the series is non-stationary. This means that the time series is stationary, making it suitable for time-series forecasting using models like ARIMA.

These results suggest that the global ESG values show a steady upward trend, with relatively small fluctuations, and are expected to continue rising in the future. The ARIMA model has been effective in capturing this trend, providing reliable forecasts for the upcoming years.

SARIMAX Results

Dep. Variable:	ESG Value	No. Observations:	22
Model:	ARIMA(1, 1, 1)	Log Likelihood	9.464
Date:	Fri, 28 Feb 2025	AIC	-12.927
Time:	14:22:30	BIC	-9.793
Sample:	01-01-2000 - 01-01-2021	HQIC	-12.247
Covariance Type:	opg		

	coef	std err	z	P>|z|	[0.025	0.975]
ar.L1	0.9960	0.014	69.502	0.000	0.968	1.024
ma.L1	-0.3912	0.482	-0.812	0.417	-1.335	0.553
sigma2	0.0196	0.008	2.575	0.010	0.005	0.035

Ljung-Box (L1) (Q):	4.55	Jarque-Bera (JB):	0.41
Prob(Q):	0.03	Prob(JB):	0.81
Heteroskedasticity (H):	0.39	Skew:	0.32
Prob(H) (two-sided):	0.24	Kurtosis:	2.75

Warnings:
[1] Covariance matrix calculated using the outer product of gradients (complex-step).

Figure 11. SARIMAX Results

The SARIMAX results for the ARIMA (1,1,1) model show the parameters that best fit the data. The coefficient for ar.L1 (autoregressive term) is 0.9960, which is significant, suggesting a strong relationship with past values. The ma.L1 (moving average term) is -0.3912, indicating a moderate influence of residuals from previous periods. The sigma value (error variance) is 0.0196, reflecting the noise in the data. The model fit is significant with a log-likelihood of 9.464, AIC of -12.927, and BIC of -9.793, suggesting that the ARIMA (1,1,1) model is a good fit for forecasting.

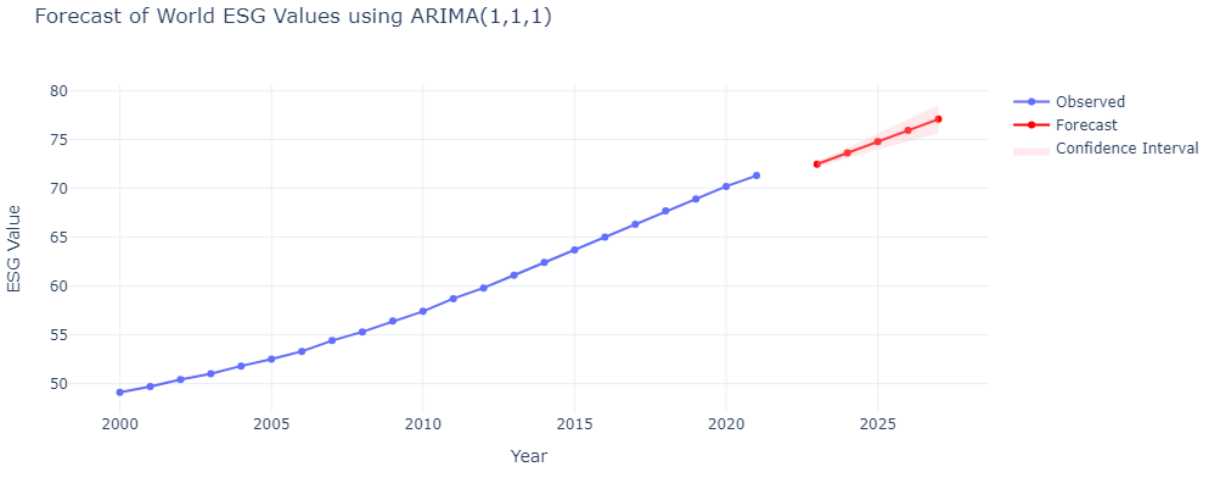

Figure 12. Forecast of World ESG Values using ARIMA (1,1,1)

The forecast chart shows predicted ESG values for the years 2022 to 2025 based on the ARIMA (1,1,1) model. The forecasted values continue the upward trend observed in the historical data, with a widening confidence interval, indicating increasing uncertainty in the further future. The forecast confirms that global ESG values are expected to keep rising.

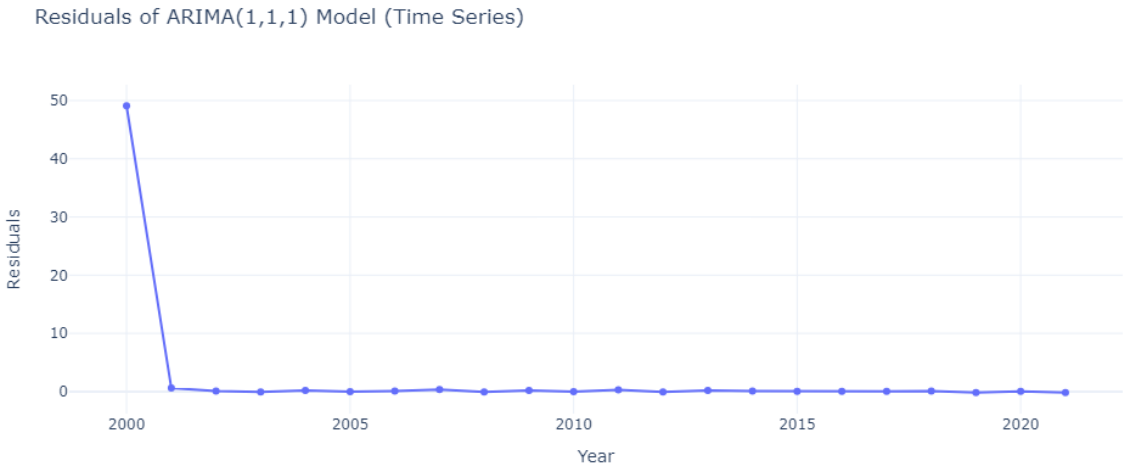

Figure 13. Residuals of ARIMA(1,1,1) Model (Time Series)

The residual plot shows the difference between the observed and predicted ESG values. The residuals are close to zero for most years, suggesting that the model accurately captures the underlying trends in the data. However, a significant spike around 2000 may suggest an anomaly or outlier in that period.

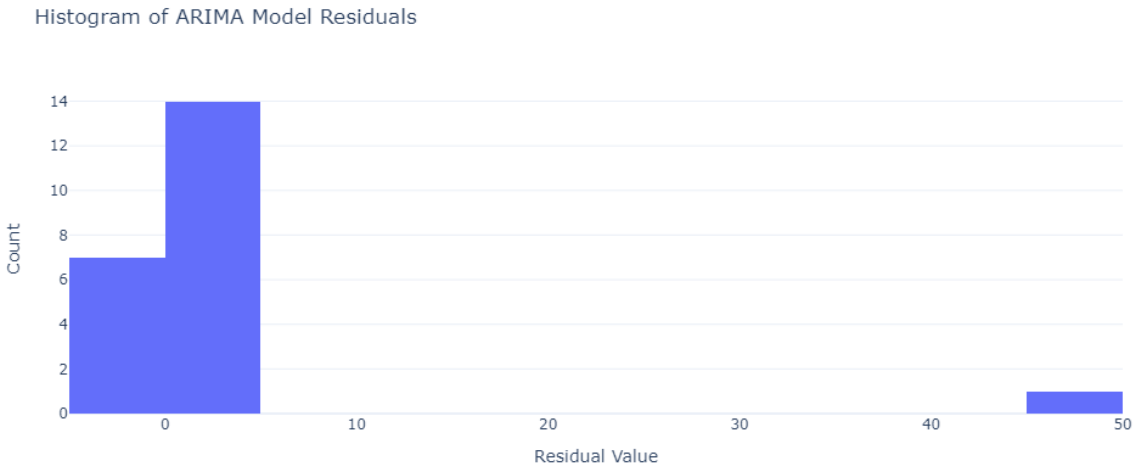

Figure 14. Histogram of ARIMA Model Residuals

The histogram of the residuals shows a heavy concentration of values close to zero, with a few larger residuals indicating occasional outliers. This suggests that the ARIMA (1,1,1) model is generally effective in capturing most of the variability in the data, but occasional large deviations do occur.

d. Data Analytics Technique: K-Means Clustering Analysis

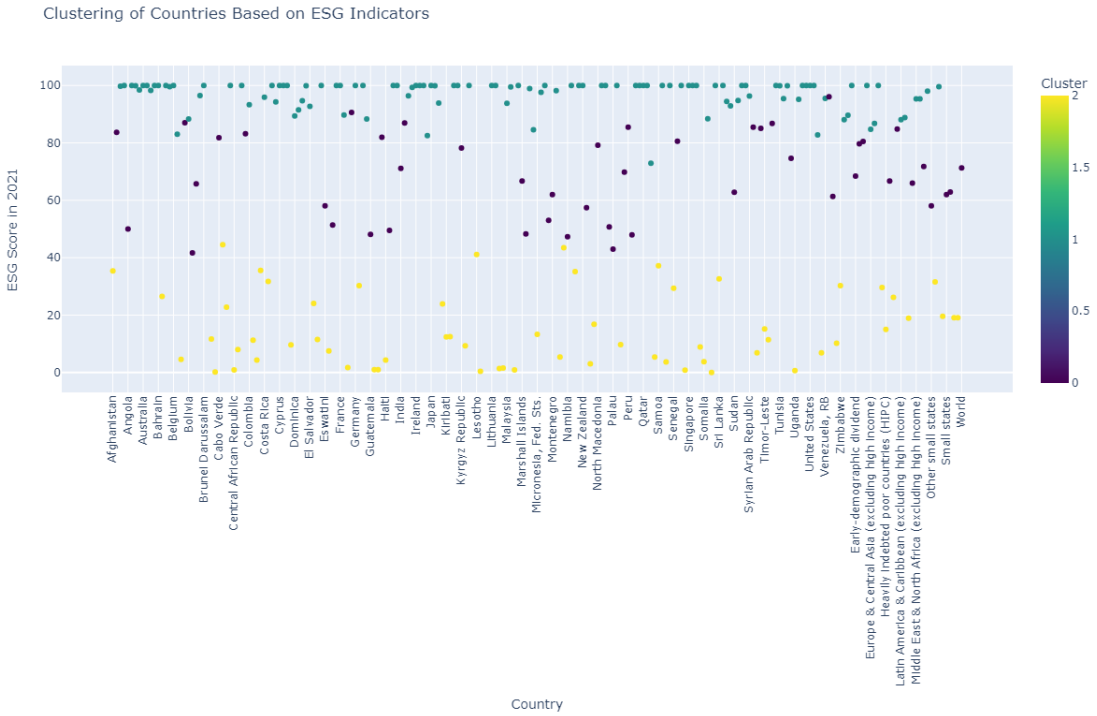

Figure 15. Clustering of Countries Based on ESG Indicators

Cluster distribution helps identify regional trends and tailor interventions, focusing on clean energy and sustainability. The scatter plot groups countries into three clusters based on their 2021 ESG scores:

- Yellow Cluster: Countries with low ESG scores (below 50), primarily from lower-income regions with limited access to clean energy and sustainable technologies.
- Green Cluster: Countries with moderate ESG scores (mid-50s to mid-70s), making progress toward sustainability but facing challenges.
- Purple Cluster: Countries with high ESG scores (above 80), indicating strong access to clean fuels and technologies, typically high-income countries with advanced infrastructure.

Country Distribution

- High ESG: Countries like Australia, France, and Germany are in the purple cluster, showing strong sustainability efforts.
- Moderate ESG: Countries like India and South Africa are in the green cluster, improving but with room for growth.
- Low ESG: Countries like Afghanistan and Angola are in the yellow cluster, facing challenges in clean energy access and environmental sustainability.

The plot highlights global disparities in ESG performance, with high-income countries outperforming low-income nations, indicating areas for targeted interventions.

IV. Interpretation of Results in the Context of ESG

a. Relation of Findings to an ESG Goal

The findings from the ESG data analysis, derived from the World Bank dataset, directly relate to key Environmental, Social, and Governance (ESG) goals, particularly in the areas of environmental sustainability and social impact, with a specific focus on Access to Clean Fuels and Technologies for Cooking. The increasing global ESG values reflect progress toward improving access to clean cooking solutions, which aligns with the Affordable and Clean Energy (SDG 7) and Climate Action (SDG 13) goals. The upward trend in ESG scores, especially in higher-income countries, demonstrates a global movement toward reducing reliance on traditional, harmful fuels like biomass and coal, and enhancing the availability of cleaner, more sustainable cooking technologies.

b. Contribution of the Analysis to the Achievement of Specific ESG Objectives

Meanwhile, the analysis of the World Bank dataset contributes to the achievement of ESG objectives by identifying key trends and disparities in access to clean cooking technologies across different regions and income groups. The findings highlight which regions have made significant progress in improving access to clean cooking and which are still facing challenges. The forecasted trends provide valuable insights into future ESG developments, helping policymakers and organizations prioritize efforts in regions with lower scores, such as Sub-Saharan Africa and South Asia. This analysis emphasizes the need for targeted actions to enhance their access to clean cooking technologies, reduce harmful pollutants, and address broader environmental and social sustainability challenges.

V. Ethical Considerations Related to ESG

a. Address ethical issues related to fairness, inclusivity, and bias in your data and models

When analyzing Access to Clean Fuels and Technologies for Cooking using data from the World Bank, it is important to address fairness, inclusivity, and potential biases in both the data and the models. The dataset might overrepresent high-income countries, where clean cooking technologies are more prevalent, and underrepresent low-income countries where access to clean cooking remains limited. This imbalance could lead to biases in the conclusions, as it may overlook the challenges faced by poorer regions in adopting clean cooking solutions. Ensuring fairness means paying attention to the unequal access to data and the varying adoption rates of clean cooking technologies across countries.

b. Whether your data is representative of diverse groups

The World Bank dataset includes a wide range of countries, but it may not fully represent the diverse experiences within each group. Specifically, low-income and rural communities in developing countries might not be adequately represented due to limited data collection in these regions. The dataset could also lack information on the specific barriers to adopting clean cooking solutions in these areas, such as cultural preferences or the availability of necessary infrastructure. This could result in an incomplete understanding of the challenges facing the most vulnerable populations.

c. Is your data reflective of a real-world data set?

While the World Bank dataset reflects global trends in access to clean cooking fuels and technologies from 2000 to 2021, it may not fully capture the complexities of the real-world situation. Socioeconomic and cultural factors, local policies, and unique regional challenges often influence the adoption of clean cooking technologies, and these aspects may not be fully reflected in quantitative data alone. Moreover, while the dataset provides valuable insights, it might not always capture the most up-to-date developments, such as recent technological innovations or policy changes.

d. Ways to improve realistic conclusion in your analysis and predictions

To enhance the realism and accuracy of conclusions and predictions, the following steps can be taken: expand data sources by incorporating additional information from local organizations, governments, or NGOs to provide a fuller picture of clean cooking access, especially in underrepresented regions; account for socio-economic and cultural factors by including qualitative data like surveys, interviews, and community feedback to better understand adoption influences; adjust for regional biases using statistical methods to correct for underrepresentation of low-income countries or rural areas; update data regularly to include the latest information on clean cooking technologies, policies, and global events such as the COVID-19 pandemic; and incorporate local context by gathering more granular data on barriers to clean cooking adoption, considering local governance, infrastructure, and community attitudes. Addressing these factors would improve the analysis and provide a more accurate and actionable perspective on achieving universal access to clean cooking technologies.

VI. References

ChatGPT. (2025). Chatgpt.com. https://chatgpt.com/c/67c1c131-f928-8002-835b-37efab22819c

Dimitrios Asteriou, Pilbeam, K., Ioannis Litsios, & Pouliot, W. (2024). ESG Ratings and Investment Returns at the Country Level: Does Higher Mean Better? *International Journal of Finance & Economics*. https://doi.org/10.1002/ijfe.3090

IEA. (2022). *Access to clean cooking – SDG7: Data and Projections – Analysis*. IEA. https://www.iea.org/reports/sdg7-data-and-projections/access-to-clean-cooking

VII. Appendix I. Actionable Recommendations

1. **Targeted Investment in Low-Income and Rural Areas**: Invest heavily in infrastructure and technology deployment in low-income countries, especially in Sub-Saharan Africa and South Asia, where access to clean cooking is limited. This could involve setting up government and international financial programs that provide grants or subsidies for the purchase of clean cooking technologies, such as improved cookstoves, biogas systems, and solar cookers. International agencies, such as the World Bank, and regional development organizations should collaborate to create funding initiatives to support low-income communities. Additionally, investments in clean cooking infrastructure such as renewable energy grids and distribution channels are critical to overcoming supply chain barriers.

2. **Develop and Enforce Supportive Policies and Regulations**: Governments should create or strengthen policies that incentivize the adoption of clean cooking technologies. This could include tax breaks, subsidies, and low-interest loans for households to purchase clean cooking stoves, and supporting policies for clean fuel production. Regulations that ensure product quality and safety should be enforced to protect consumers. Establishing a clear regulatory framework for clean cooking technologies will foster greater trust in these solutions, making it easier for people to transition from traditional fuels to cleaner alternatives.

3. **Local Production and Distribution Networks**: Strengthen local production and distribution systems for clean cooking technologies to reduce costs and ensure accessibility. Establish local manufacturing hubs for cookstoves, solar cookers, and biogas systems, supported by public-private partnerships. Localized distribution models, such as working with rural cooperatives, can make it easier for people in remote areas to access affordable and reliable clean cooking solutions. This will help overcome logistical challenges in remote and underserved regions and reduce the carbon footprint of transportation.

4. **Comprehensive Awareness and Education Campaigns**: A comprehensive, community-focused education campaign should be launched to raise awareness about the health, environmental, and economic benefits of clean cooking technologies. These campaigns should use a variety of platforms—community meetings, social media, radio, and television to reach different demographics, especially women and rural communities who are more likely to adopt clean cooking solutions. Community engagement programs that involve local leaders, such as health workers and community organizers, will help overcome cultural barriers and encourage wider adoption.

5. **Affordable Financing Models for Low-Income Households**: To overcome financial barriers, implement microfinance and pay-as-you-go models that allow low-income households to purchase clean cooking solutions without upfront costs. Working with microfinance institutions and fintech companies to develop tailored financing products can provide affordable loans and flexible payment schedules. These models can also incorporate mobile payment systems, which are widely used in many developing countries. Creating financing options that align with household income cycles will make it easier for people to access clean cooking technologies.

6. **Improve Data Collection and Address Data Gaps**: Strengthen the collection of granular, region-specific data to better understand the barriers to clean cooking adoption in different countries. Collaborate with local governments, NGOs, and community organizations to gather qualitative and quantitative data, such as surveys, interviews, and focus groups, to

better understand the socio-economic, cultural, and infrastructural challenges that hinder the adoption of clean cooking technologies. This localized data will be critical in designing effective interventions and policies that are tailored to the specific needs of each region.

7. **Promote Public-Private Partnerships for Technology Innovation**: Encourage collaboration between governments, NGOs, and the private sector to foster innovation in clean cooking technologies. By creating public-private partnerships (PPPs), governments can leverage the resources and expertise of private companies in technology development, distribution, and scaling. PPPs can help accelerate the development of more affordable, efficient, and culturally appropriate cooking solutions. Government support for research and development in clean cooking technologies could lead to breakthroughs that lower costs and improve performance, making them more accessible to the world's poorest populations.
8. **Strengthen Regional and International Cooperation**: Foster regional and international cooperation to share knowledge, technologies, and funding for clean cooking solutions. Regional coalitions can be established to facilitate cross-border initiatives in technology development, capacity building, and awareness campaigns. Additionally, countries can learn from successful models in other regions to adopt best practices in clean cooking technology and policy implementation. Global institutions such as the United Nations, World Bank, and the Global Alliance for Clean Cookstoves can facilitate cooperation and provide financial support to national and regional projects.

By implementing these recommendations, a comprehensive and sustainable approach to addressing the global clean cooking challenge can be established, targeting both immediate and long-term goals. The combination of targeted investments, policy reforms, education, and innovative financing models can transform access to clean cooking solutions, especially in low-income regions, contributing to broader ESG goals and ensuring equitable, sustainable development.