Data Science : Journal Of Computing And Applied Informatics
Journal homepage: https://jocai.usu.ac.id

Deciphering the Key Drivers of Sustainability: Harnessing Artificial Intelligence in Data Analytics to Unravel the Dynamics of Decarbonisation in Pursuit of Sustainable Development

Harry Patria[*1] and Djuwita A. Rahim[2]
[1]*University of Strathclyde, Glasgow, G1 1XQ, United Kingdom*
[2]*BINUS University, Jakarta, 11480, Indonesia*
[*]Corresponding Author: harry.patria@sbm-itb.ac.id

ARTICLE INFO

Article history:
Received 22 December2023
Revised 22 April 2024
Accepted 22 April 2024
Available online 31 July 2024

E-ISSN: 2580-829X
P-ISSN: 2580-6769

How to cite:
Harry Patria and Djuwita A. Rahim "Deciphering the Key Drivers of Sustainability: Harnessing Artificial Intelligence in Data Analytics to Unravel the Dynamics of Decarbonisation in Pursuit of Sustainable Development", Data Science : Journal Of Computing And Applied Informatics Vol.8, No.2, July 2024, doi : http://doi.org/10.32734/jocai.v8.i2-15005

ABSTRACT

In the epoch where climate change poses an existential threat to humanity, understanding the intricate dynamics of CO2 emissions is more critical than ever. This study embarks on an ambitious journey to unravel the complex interplay of factors influencing carbon emissions, leveraging the prowess of Artificial Intelligence (AI) and the analytical capabilities of Power BI. Anchored in the context of the United Nations' Sustainable Development Goals (SDGs), this research transcends traditional analytical boundaries, offering a novel lens to view and interpret environmental data. At the heart of this exploration lies the UN SDG dataset, a rich tapestry of environmental, economic, and social indicators. The study's methodology is a fusion of advanced AI techniques with Power BI's visualization influencers, a combination that not only promises precision but also an unprecedented depth of insight. Power BI leverages ML.NET's SDCA (Stochastic Dual Coordinate Ascent) regression to find the best-fit line and ML.NET's L-BFGS (Limited-memory Broyden–Fletcher–Goldfarb–Shanno) algorithm used for logistic regression to predict the categorical outcome. This dual approach enables a multifaceted analysis, capturing the nuances and subtleties often lost in conventional studies. The findings of this research are both revealing and transformative. They shed light on the significant yet varied factors that drive CO2 emissions across different geographical and socio-economic landscapes. The study unveils a striking correlation between increased access to electricity and GDP per capita with rising carbon emissions, a pattern particularly pronounced in developing regions. Conversely, in more developed contexts, the analysis reveals a complex interplay between emissions, literacy rates, and fertility rates, suggesting indirect yet potent pathways through which socio-economic development influences environmental outcomes. The insights gleaned offer a beacon for policymakers, illuminating the pathways to tailor environmental strategies that resonate with the unique needs of different regions. For developing nations, the study advocates for policies that intertwine educational and family planning initiatives with environmental objectives. In contrast, for developed countries, it underscores the need for technological innovation and efficiency improvements. The study's innovative use of AI and Power BI sets a new precedent in environmental research, demonstrating the immense potential of these tools in shaping sustainable futures.

Keyword: Sustainable Development Goals (SDGs), Artificial Intelligence (AI), CO2 Emissions Analysis, Data-Driven Sustainability, Socio-Economic Factors

ABSTRAK

Di era di mana perubahan iklim menimbulkan ancaman eksistensial bagi umat manusia, pemahaman tentang dinamika rumit emisi CO2 menjadi lebih kritis dari sebelumnya. Studi ini, berjudul memulai perjalanan ambisius untuk mengungkap interaksi kompleks faktor-faktor yang mempengaruhi emisi karbon, dengan memanfaatkan kecanggihan Kecerdasan Buatan (AI) dan kemampuan analitis Power BI. Berakar pada konteks Tujuan Pembangunan Berkelanjutan (Sustainable Development Goals - SDGs) Perserikatan Bangsa-Bangsa, penelitian ini melampaui batas analitis tradisional, menawarkan perspektif baru untuk melihat dan menafsirkan data lingkungan. Inti dari eksplorasi ini terletak pada dataset SDG PBB, sebuah kumpulan data yang kaya akan indikator lingkungan, ekonomi, dan sosial. Metodologi studi ini adalah gabungan dari teknik AI canggih dengan influencer visualisasi Power BI, kombinasi yang tidak hanya menjanjikan presisi tetapi juga kedalaman wawasan yang belum pernah ada sebelumnya. Power BI memanfaatkan regresi SDCA (Stochastic Dual Coordinate Ascent) ML.NET untuk menemukan garis yang paling sesuai dan algoritma L-BFGS (Limited-memory Broyden–Fletcher–Goldfarb–Shanno) ML.NET yang digunakan untuk regresi logistik guna memprediksi hasil kategorikal. Pendekatan ganda ini memungkinkan analisis multifaset, menangkap nuansa dan subtleti yang sering hilang dalam studi konvensional. Temuan penelitian ini bersifat mengungkap dan transformatif. Mereka menyoroti faktor-faktor penting namun bervariasi yang mendorong emisi karbon di berbagai lanskap geografis dan sosial-ekonomi. Studi ini mengungkap korelasi mencolok antara peningkatan akses ke listrik dan PDB per kapita dengan peningkatan emisi karbon, pola yang sangat menonjol di wilayah berkembang. Sebaliknya, dalam konteks yang lebih maju, analisis mengungkap interaksi kompleks antara emisi, tingkat literasi, dan tingkat fertilitas, menunjukkan jalur tidak langsung namun kuat di mana pembangunan sosial-ekonomi mempengaruhi hasil lingkungan. Wawasan yang diperoleh menawarkan panduan bagi pembuat kebijakan, menerangi jalur untuk menyesuaikan strategi lingkungan yang sesuai dengan kebutuhan unik berbagai wilayah. Untuk negara-negara berkembang, studi ini menganjurkan kebijakan yang menggabungkan inisiatif pendidikan dan perencanaan keluarga dengan tujuan lingkungan. Sebaliknya, untuk negara-negara maju, studi ini menekankan perlunya inovasi teknologi dan peningkatan efisiensi. Penggunaan AI dan Power BI yang inovatif dalam studi ini menetapkan preseden baru dalam penelitian lingkungan, menunjukkan potensi besar alat-alat ini dalam membentuk masa depan yang berkelanjutan.

Keyword: Tujuan Pembangunan Berkelanjutan (SDGs), Kecerdasan Buatan (AI), Analisis Emisi CO2, Keberlanjutan Berbasis Data, Faktor Sosial-Ekonomi

http://doi.org/10.32734/jocai.v8.i2-15005

1 Introduction

In an era marked by the escalating crisis of climate change, the imperative to understand and mitigate its impacts has never been more critical. The rise in CO_2 emissions, a primary driver of global climate change, is a consequence of human activities like fossil fuel combustion and deforestation. This phenomenon, as highlighted by the Intergovernmental Panel on Climate Change [1], presents an existential threat to humanity, necessitating a deeper understanding of its dynamics and effective strategies to curb its rise. The intricate interplay of carbon emissions with various global factors forms the crux of contemporary environmental research, echoing a universal call for immediate and sustained action to address this challenge [2].

The expansion of electricity access worldwide has been a hallmark of economic development over the last two decades found in Figure 1. This increase in electricity access has been paralleled by a rise in GDP and, concomitantly, an uptick in CO2 emissions. Notably, in 2000, Luxembourg stood as an exemplar of wealth, with the highest GDP per capita at $114,889, contrasting starkly with Mozambique, which had the lowest at just $437.

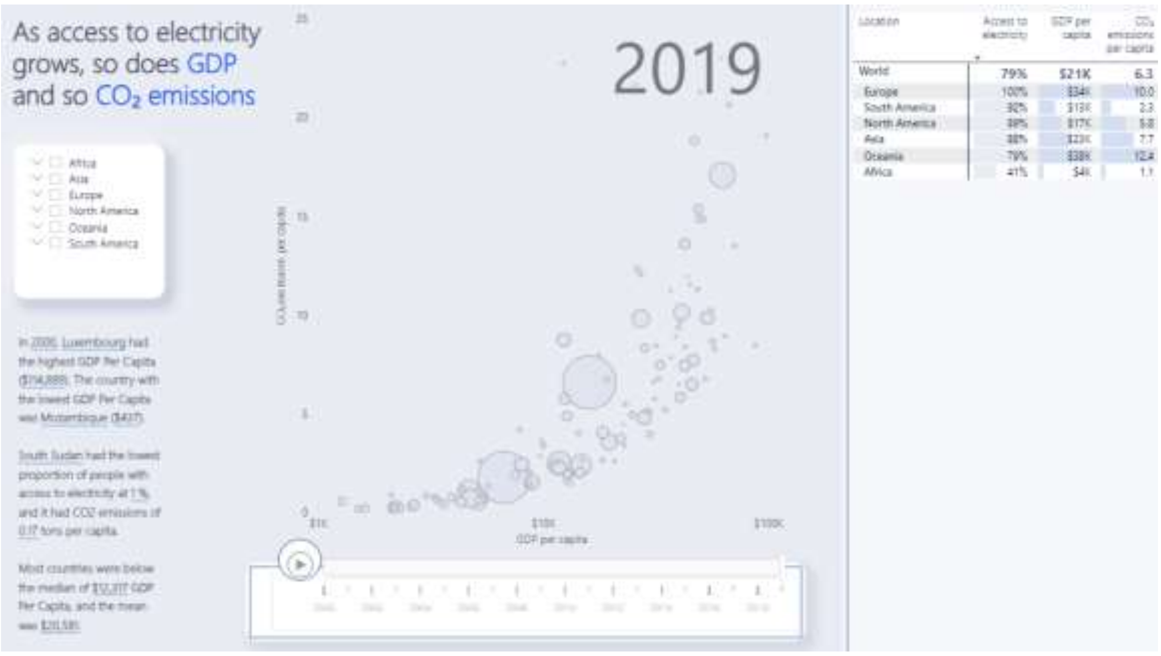
South Sudan, with only 1% of its population having access to electricity, had CO2 emissions of 0.17 tons per capita, highlighting a pattern where limited access to electricity correlates with lower emissions but also points to significant developmental challenges. Most countries fell below the median GDP per capita of $12,317, with the mean at $20,581, indicating a skewed distribution of wealth and, by extension, access to energy and associated emissions. The data illuminates a multifaceted relationship: as nations climb the economic ladder, marked by increased access to electricity and higher GDP per capita, their CO2 emissions also rise. This correlation suggests that economic growth, as it currently stands, comes with an environmental cost - a globally evident pattern.

In 2019, regions such as Europe and North America, with near-universal access to electricity and high GDP per capita levels of $34k and $52k respectively, had correspondingly substantial CO2 emissions per capita at 10.0 and 7.7 tons. In contrast, Africa, with the least access to electricity and a GDP per capita of $4k, had the lowest CO2 emissions per capita at 1.1 tons. This contrast poses a conundrum for sustainable development: how to continue improving access to electricity - which is essential for economic development and improving the quality of life - without exacerbating CO2 emissions.

In analyzing these patterns, policymakers must grapple with the complex task of decoupling economic growth from carbon emissions. The case of Luxembourg and Mozambique exemplifies the extremes of this spectrum. Luxembourg's high GDP per capita and CO2 emissions may reflect a high-energy-consuming lifestyle that many countries aspire to but is environmentally unsustainable. Mozambique's position reflects a developmental stage where increasing access to electricity is a priority, which could lead to increased emissions if not managed sustainably.

At the forefront of this global effort are the United Nations' Sustainable Development Goals (SDGs), which offer a blueprint for addressing a range of challenges, including the pressing issue of climate change. SDG 13, in particular, emphasizes the need for urgent actions to combat climate change and its [3]. This goal underscores the importance of integrating environmental sustainability into broader socio-economic development plans, a perspective that is increasingly being recognized as crucial for achieving these ambitious objectives.

The advent of Artificial Intelligence (AI) and advanced data analytics has revolutionized the landscape of environmental research. AI's ability to process and analyze large datasets has opened new avenues for uncovering patterns and deriving insights that were previously elusive. This technological advancement, coupled with the analytical capabilities of tools like Power BI, as demonstrated in the work of [4], offers significant potential in identifying and interpreting complex environmental data. The integration of AI with Power BI's visualization tools enables a more nuanced and dynamic exploration of environmental data, promising a depth of insight that traditional analytical methods may not achieve.



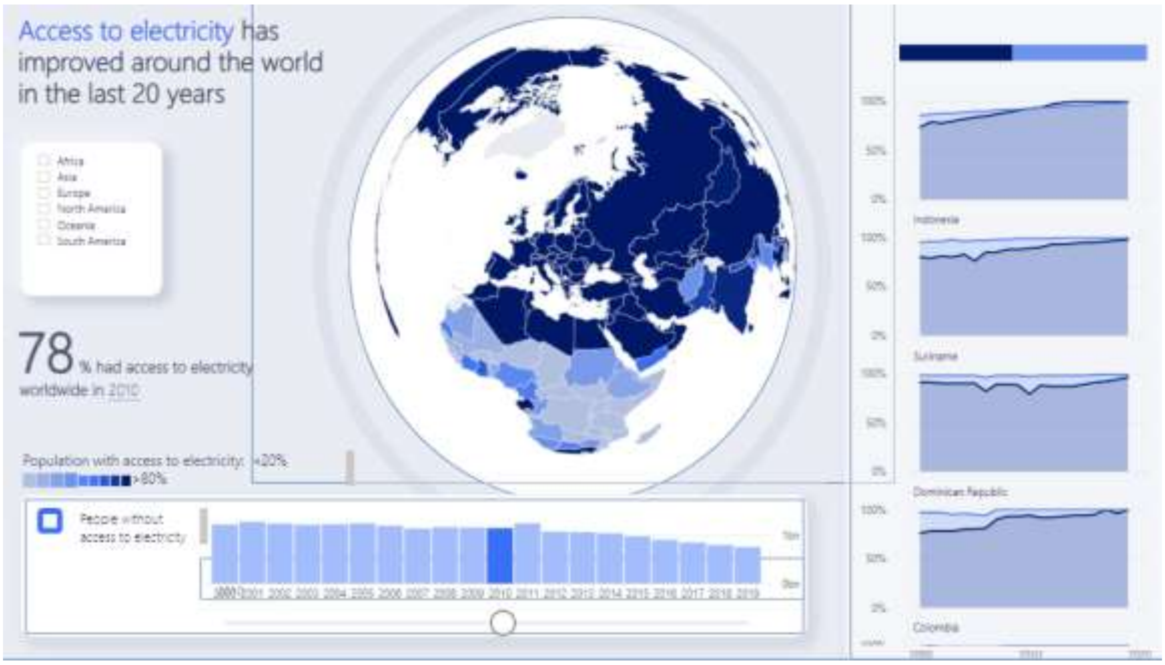


Figure 1. Carbon emissions and access to electricity across countries
Source: Modified from Thompson (2022)

Recent studies have shed light on the complex relationship between socio-economic factors and CO_2 emissions. Factors such as access to electricity, GDP per capita, literacy rates, and fertility rates have been identified as significant influencers of emissions. This relationship, however, is not uniform across different geographical and developmental contexts. In developing regions, for instance, the correlation between increased access to electricity and GDP per capita with rising CO_2 emissions is particularly pronounced. In contrast, in more developed contexts, the interplay between emissions, literacy rates, and fertility rates suggests indirect yet potent pathways through which socio-economic development influences environmental outcomes [5;6;7;8;9]

The objective of this study is to harness the capabilities of AI and Power BI in analyzing the UN SDG dataset, with a focus on unraveling the complex factors influencing carbon emissions. By integrating advanced AI techniques with Power BI's visualization influencers, this research seeks to provide deeper insights into the drivers of CO_2 emissions and inform effective policy interventions. This study not only contributes to the academic discourse on environmental sustainability but also provides practical, actionable insights for policymakers and stakeholders.

The structure of this study is methodically laid out to guide the reader through its various facets. Following this introduction, Chapter 2 delves into the literature review and the methodology, elucidating the data sources and analytical techniques employed. Chapter 3 presents the results, offering a comprehensive analysis of the findings. Chapter 4 engages in a detailed discussion, interpreting the results in the context of existing literature and exploring their implications for policy and practice. Finally, Chapter 5 concludes the study, summarizing the key findings and suggesting directions for future research.

2 Literature Review

The literature on climate change and CO_2 emissions is extensive and multifaceted, reflecting the complexity of the issue. Central to this discourse is the recognition of carbon emissions as a primary contributor to global warming and climate change. The Intergovernmental Panel on Climate Change (IPCC, 2021) has consistently highlighted the critical role of human activities in escalating CO_2 levels, leading to significant environmental and socio-economic impacts. This understanding forms the foundation of global efforts to mitigate climate change, as encapsulated in the United Nations' Sustainable Development Goals (SDGs). Specifically, SDG 13 emphasizes the need for urgent action to combat climate change and its impacts [3]

In recent years, the focus has shifted towards understanding the socio-economic drivers of CO_2 emissions. Studies have shown a complex relationship between emissions and factors such as economic development, energy consumption, and demographic changes. For instance, Patria [5;6;7;8;9) explored the interplay between

economic indicators and environmental outcomes. These studies underscore the nuanced nature of this relationship, varying significantly across different geographical and developmental contexts.
The advent of AI and advanced data analytics has opened new avenues in environmental research. AI's capability to process and analyze large datasets has been instrumental in identifying patterns and insights in environmental data. Patria et al. (2019) have demonstrated the potential of AI in strategic decision-making within the business and management field, a principle that is equally applicable in environmental studies. Furthermore, the use of visualization tools like Power BI, as discussed by [4], enhances the ability to interpret complex data, making it a valuable tool in environmental analysis.

3 Methodology

3.1 Data Source and Preprocessing

The data for the study comes from two primary sources: the United Nations Sustainable Development Goals (UN SDG) data and the World Bank data. The UN SDG data, available at https://unstats.un.org/sdgs/unsdg , includes a wide range of indicators from the years 2000 to 2020 that shed light on various aspects of sustainability including environmental, economic, and social factors that influence carbon dioxide emissions. In addition, data from the World Bank, which can be accessed at https://datacatalog.worldbank.org , likely provides economic indicators such as GDP, which are essential for understanding the economic dimensions of CO2 emissions.

The study also incorporates narrative elements adapted from Max Roser's "The world’s energy problem," which discusses the complexities of the world's energy challenges in relation to CO2 emissions. This narrative can be found within the content of "Our World in Data," a reliable source for research and data visualization on large global problems. The specific article and associated charts are adapted from a section that can be found at https://ourworldindata.org/energy-problem. These sources combined offer a rich, data-driven framework for analyzing the intricacies of CO2 emissions within the broader context of sustainable development. Data preprocessing involved cleaning and structuring the dataset for analysis [12;7;8;9]. This step ensured the removal of inconsistencies and missing values, making the data suitable for AI analysis. This multifaceted approach—melding data from prominent global institutions with scholarly interpretation—empowers a robust and holistic analysis of CO2 emissions, revealing the delicate balance between sustaining economic growth and safeguarding the environment.

3.2 AI Technique and Power BI Visualization

The study employed advanced AI techniques for data analysis. Machine learning algorithms were used to identify patterns and relationships within the data. The use of Power BI’s visualization influencers provided an interactive platform for exploring these relationships (13;9;14;15;16;17]. The Key Influencer feature in Microsoft Power BI employs machine learning (ML) and artificial intelligence (AI) to identify factors that significantly affect a target metric or Key Performance Index. This dual approach allowed for a multifaceted analysis, capturing nuances often overlooked in traditional studies.

The analytical framework was designed to explore the relationship between socio-economic factors and CO_2 emissions. The framework utilized AI to analyze the data, while Power BI tools were used to visualize the findings, facilitating a deeper understanding of the underlying patterns and trends [13;9].

3.2.1 Linear Regression in Key Influencers

Linear regression is applied to numerical data. It aims to find a linear relationship between the independent variables $x_1, x_2, .., x_n$ and the dependent variable y. The mathematical model for linear regression is (Sufi, 2021; 2022a;2022b; Sufi & Alsulami, 2021):

$$y = b_0 + b_1 x_1 + \varepsilon \qquad (1)$$

Where:
y is the dependent variable (response)
x_1 is an independent variable (predictor)

b_1 is the slope indicsating the change of y per unit change in x_1
b_0 is the model intercept
ε represents the random error
Power BI leverages ML.NET's SDCA (Stochastic Dual Coordinate Ascent) regression to find the best-fit line, which accurately predicts the output for the continuous dependent variable y, establishing a linear relationship as modeled in equation (1).

3.2.2 Logistic Regression in Key Influencers

For categorical data, logistic regression is utilized. It models the probability of a categorical event occurring, and the mathematical model is expressed as [14;15;16;17]:

$$Log(P/(1-P)) = b_0 + b_1x_1 + b_2x_2 + .. + b_nx_n \quad (2)$$

Where:
P is the probability of the event Y occurring
$x_1, x_2, .., x_n$ are independent variables (predictors)

$b_1, b_2, .., b_n$ are the slope indicating the change of $Log(P/(1-P))$ per unit change in x
b_0 is the model intercept

ML.NET's L-BFGS (Limited-memory Broyden–Fletcher–Goldfarb–Shanno) algorithm is used for logistic regression to predict the categorical [14;15;16;17]. The decision tree is another technique used in Power BI to identify significant subgroups or segments within the data. It looks at data trends within one group relative to others and selects factors that offer the best data splits, aiming for subsets that are significant in the metric of interest. The Key Influencers visualization illustrates top contributors to a selected metric value. It uses regression analysis to quantify the impact of explanatory variables. Additionally, it utilizes decision trees to highlight interesting subgroups and their contribution to the metric. The strength of the relationship between variables is quantified by coefficient correlation, which ranges from $[-1,1]$. The Key Influencers visualization employs the Wald test to determine whether an explanatory variable is a significant influencer of the target variable, using a threshold of 0.05 p-value for significance. In essence, Power BI's Key Influencers visualization integrates ML and statistical analysis to offer a comprehensive tool for identifying and visualizing the variables most critical to the outcome being studied.

4 Results and Discussion

4.1 Analyzing Factors that Decrease CO_2 Emissions

Our analysis found in Figure 2, leveraging Power BI AI, reveals a complex interplay between socio-economic factors and their impact on carbon emissions. The data highlights a significant negative correlation between a high increase in literacy rates, cleaner energy for electricity and CO_2 emissions, with a substantial decrease of 4.12 units, followed by access to clean fuel for cooking (4.05 units) and life expectancy (3.78 units).

These reaffirm the hypotheses that education catalyzes environmental consciousness, driving the adoption of cleaner, inclusive access and sustainable practices. This suggests that education can be a powerful tool in promoting environmental awareness and could contribute to the adoption of cleaner technologies and practices. The role of education in environmental stewardship cannot be overstated. Enhancing literacy rates, particularly in sustainable development and environmental sciences, can lead to a more informed public that actively supports and engages in carbon reduction practices.

Additionally, it suggests that investments in education can have long-term payoffs in terms of environmental benefits. Additionally, the analysis shows that a very high decrease in the reliance on coal for electricity generation is associated with a similar decrease in CO_2 emissions (4.12 units). This finding supports the strategic shift towards renewable energy sources. A high increase in access to clean fuel for cooking correlates with a 4.05 reduction in CO_2 emissions, emphasizing the importance of clean cooking initiatives in environmental policies.

Further exploration of the data uncovers that life expectancy changes, with a high increase contributing to a decrease of 3.78 in CO_2 emissions. This could suggest that healthier populations with longer lifespans might prioritize sustainability, reflecting a long-term investment in the health of their environment as much as their own. Interestingly, when comparing regions, Europe's advancements in education and healthcare may exemplify this trend, contributing to its lower emission rates relative to Asia, where such socio-economic improvements may be more unevenly distributed.

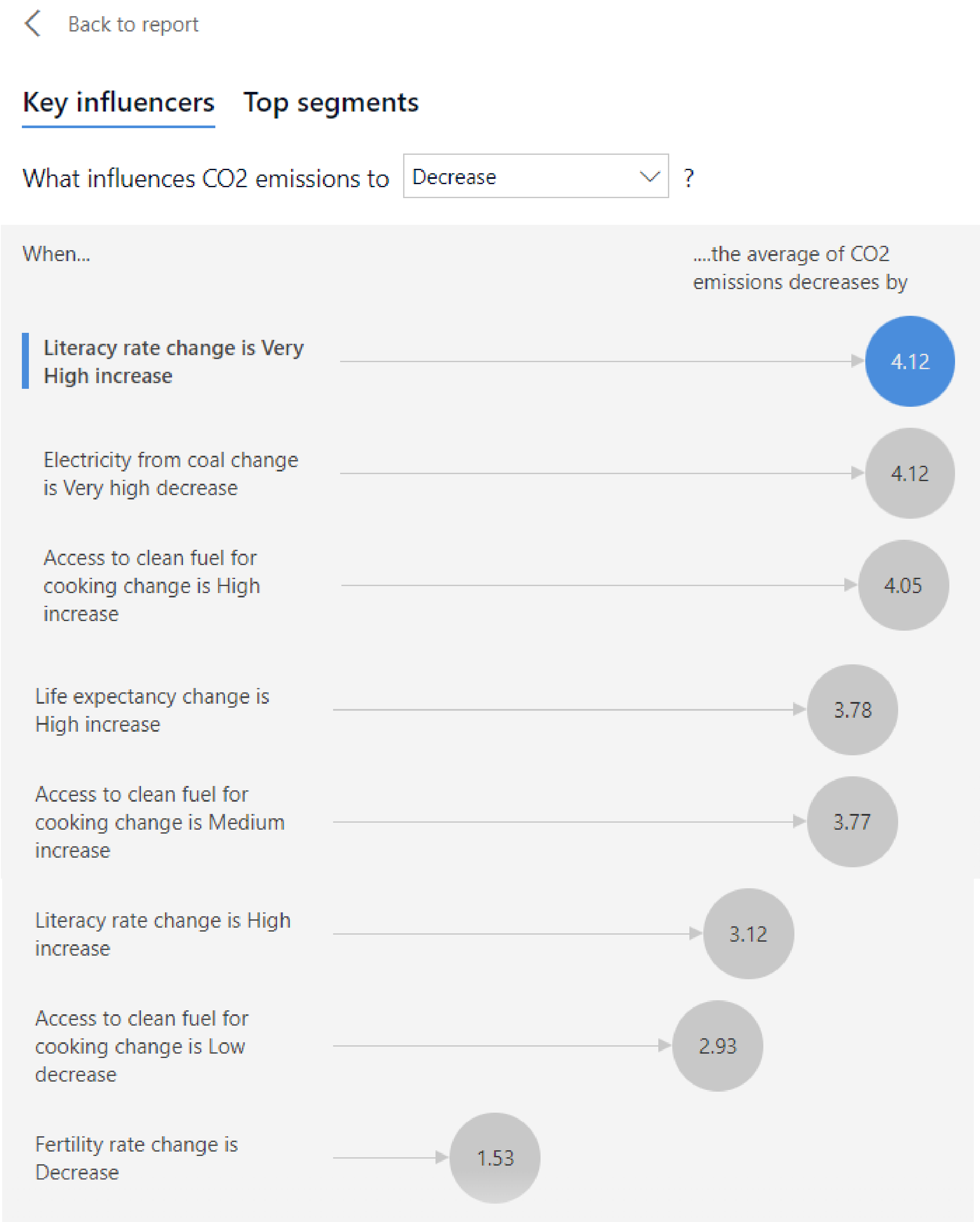


Figure 2. *Factors that Decrease CO_2 Emissions*

4.2 Analyzing Factors that Increase CO_2 Emissions

Conversely, the analysis shows that a lack of change in access to clean fuel for cooking is associated with an increase of 6.66 in CO_2 emissions found in Figure 3. This stark figure implies that maintaining the status quo in energy sources for cooking can have detrimental effects on emission levels. This ties into the broader narrative of energy poverty where, particularly in Asian regions, access to clean fuel remains a barrier to emission reduction. The move away from coal and the potential of renewable energy sources would be examined, discussing both technological advancements and the socio-economic challenges inherent in this transition.

Moreover, it can be seen that a high increase in GDP growth is associated with an increase in emissions, presenting a challenge for balancing economic development with environmental sustainability. A medium increase in GDP growth correlates with a 4.5 increase in CO_2 emissions, possibly indicating that economic activities in the developing regions of Asia are still heavily reliant on high-emission energy sources, unlike in Europe where there is a stronger shift towards green economies. The data underscores the necessity of transitioning to clean cooking fuels to mitigate emissions. It suggests that strategies focused on infrastructure development, subsidies for clean fuel technologies, and public education campaigns about the benefits of clean fuels could be effective.

The comparative analysis between Europe and Asia reveals significant insights. Europe's lower emission figures could be reflective of its advanced energy transition, robust environmental policies, and socio-economic stability. In contrast, Asia's struggle with emissions is exacerbated by its rapid industrial growth, energy infrastructure challenges, and socio-economic disparities.

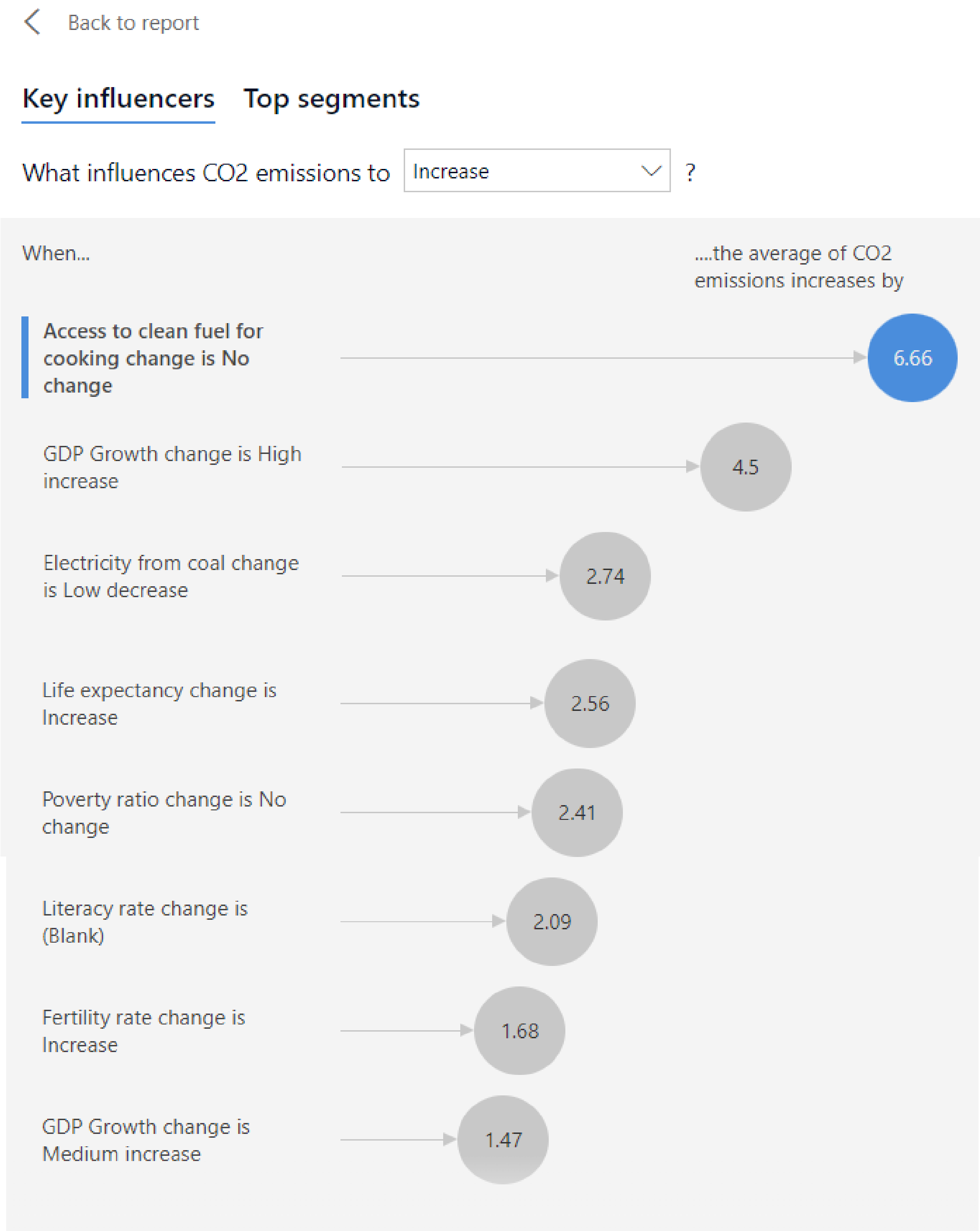


Figure 3. Factors that Increase CO2 Emissions

4.3 Top Segment Analysis

Segment analysis shown in Figure 4 revealed that certain densely populated areas have significantly high emissions (average CO_2 emissions of 12.13 with a population count of 400), pinpointing potential targets for policy interventions. These areas, potentially in rapidly industrializing regions of Asia, contrast with European counterparts, where stricter environmental regulations and more sustainable urban planning may have curbed emissions effectively.

Figure 4. High segment analysis

Conversely, some segments manage to maintain low CO_2 emissions (as low as 0.56) shown in Figure 5 despite substantial population sizes, providing case studies for successful emission control. This could indicate effective environmental management strategies that may be emulated in high-emission regions. Europe's success in this regard could be attributed to its comprehensive environmental policies and the widespread adoption of renewable energy, offering a contrast to Asia's ongoing struggle with coal dependence.

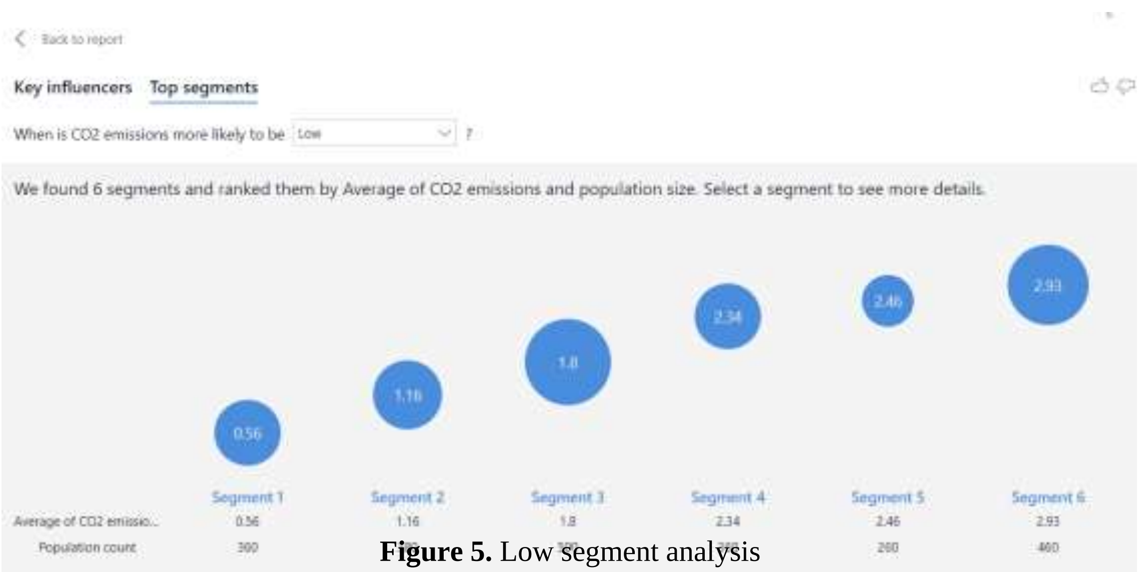


Figure 5. Low segment analysis

4.4 Implications for Policy and Sustainable Strategy

This analysis has profound implications for policy and strategy. Education and healthcare play pivotal roles in shaping a society's environmental impact. There is a clear need for policies that promote literacy and life expectancy to indirectly but effectively contribute to emission reduction. Additionally, the stark difference in emission trends between Europe and Asia suggests the need for region-specific strategies. While Europe may focus on innovation and fine-tuning its sustainable practices, Asia's policies must prioritize access to clean fuel, healthcare, and education, alongside aggressive shifts from high-emission energy sources.

5 Conclusion and Recommendation

5.1 Conclusion

This study, through the innovative use of Artificial Intelligence (AI) and Power BI, has provided a nuanced understanding of the factors influencing CO_2 emissions in the context of the United Nations' Sustainable Development Goals (SDGs). The findings reveal a complex and multifaceted relationship between CO_2 emissions and socio-economic factors, highlighting significant variations across different geographical and developmental contexts.

The analysis has shown that increased access to electricity and GDP per capita are closely linked with rising CO_2 emissions, especially in developing regions. This underscores the challenges faced by these regions in balancing economic growth with environmental sustainability. Conversely, in more developed contexts, the study has identified a complex interplay between emissions, literacy rates, and fertility rates, suggesting that socio-economic development can indirectly influence environmental outcomes.

The study has also highlighted the critical role of education and healthcare in shaping a society's environmental impact. Enhanced literacy rates and improved life expectancy are associated with reduced CO2 emissions, indicating that investments in these areas can yield significant environmental benefits.

5.2 Recommendation

Based on the findings of this study, the following recommendations are proposed to guide policymakers and stakeholders in formulating effective strategies for sustainable development:

- Tailored Environmental Policies: Develop region-specific environmental strategies that address the unique challenges and needs of different areas. For developing regions, focus on integrating environmental sustainability with economic development plans, while in developed regions, emphasize on advancing technological innovation and efficiency.
- Investment in Education and Healthcare: Prioritize investments in education and healthcare as indirect but potent tools for environmental sustainability. Enhance literacy rates and improve life expectancy to foster a society that values and actively participates in sustainable practices.
- Transition to Renewable Energy: Accelerate the transition from fossil fuels to renewable energy sources, particularly in regions heavily reliant on coal for electricity generation. Implement policies that support infrastructure development and subsidies for clean energy technologies.
- Public Awareness and Engagement: Conduct public education campaigns to raise awareness about the benefits of clean fuels and sustainable practices. Encourage public participation in environmental conservation efforts.
- Research and Innovation: Invest in research and development to innovate new technologies and practices that reduce CO_2 emissions. Encourage collaboration between governments, academia, and the private sector to drive technological advancements in sustainability.
- Monitoring and Evaluation: Implement robust monitoring and evaluation mechanisms to track the progress of environmental policies and initiatives. Use data analytics to continuously assess and refine strategies for better outcomes.

This study opens several avenues for future research. Further exploration into the causal relationships between socio-economic factors and CO_2 emissions can provide deeper insights. Additionally, research on the effectiveness of different policy interventions in various contexts can guide more targeted and impactful strategies. The potential of AI and data analytics in environmental research remains vast, and future studies should continue to leverage these tools to advance our understanding of sustainable development. All in all, this study has demonstrated the immense potential of AI and Power BI in analyzing complex environmental data, offering valuable insights for policymakers and stakeholders in their pursuit of sustainable development. The findings and recommendations provided herein aim to contribute to the global effort in combating climate change and achieving the SDGs.

REFERENCES

[1] IPCC. (2021). Climate Change 2021: The Physical Science Basis. Intergovernmental Panel on Climate Change.

[2] Smith, P., et al. (2019). "Interlinkages between CO_2 Emissions and Socio-economic Factors." Environmental Research Letters.

[3] United Nations. (2015). Sustainable Development Goals. United Nations.

[4] Thompson, W. (2022). "Analyzing the UN's Sustainable Development Goals at Gartner Data & Analytics Summit EMEA."

[5] Patria, H. (2021a). The Role of Leadership and Decision-Making under Crisis: A bibliometric analysis and scientific evolution from 1962 to 2020. Asia-Pacific Management and Business Application.

[6] Patria, H. (2021b). The Role of Success Rate, Discovery, Appraisal Spending, and Transitioning Region on Exploration Drilling of Oil and Gas in Indonesia in 2004–2015. Economics and Finance in Indonesia, 67(2), 196. https://dx.doi.org/10.47291/efi.v67i2.952.

[7] Patria, H. (2022a). Predicting the Oil Investment Decision through Data Mining: Empirical Evidence in Indonesia Oil Exploration Sector. Data Science: Journal of Computing and Applied Informatics (JoCAI), 6(1), 1-11. https://doi.org/10.32734/jocai.v6.i1-7539.

[8] Patria, H. (2022b). Predicting Fraudulence Transaction under Data Imbalance using Neural Network (Deep Learning). Data Science: Journal of Computing and Applied Informatics, 6(2), 67-80. https://doi.org/10.32734/jocai.v6.i2-8309.

[9] Patria, H. (2023a). "BUSINESS INTELLIGENCE: Intelijen Bisnis Strategi dan Teknologi yang Digunakan oleh Perusahaan untuk Analisis Data Informasi Bisnis."

[10] Patria, H. (2023b). Bayesian Regression for Predicting Price Empirical Evidence in American Real Estate. Data Science: Journal of Computing and Applied Informatics, 7(1). https://doi.org/10.32734/jocai.v7.i1-10082.

[11] Patria, H. (2023c). The Price Prediction with Bayesian Inference and Visualization: Empirical Evidence in India Real Estate. Data Science: Journal of Computing and Applied Informatics, 7(2), 69-80. https://doi.org/10.32734/jocai.v7.i2-11434.

[12] Kurniawan, A., Rifa'i, A., Nafis, M.A., Andriaswuri, N. S., Patria, H., & Purwitasari, D. (2022). Feature Selection and Sensitivity Analysis of Oversampling in Big and Highly Imbalanced Bank's Credit Data. 10th International Conference on Information and Communication Technology (ICoICT), pp. 35-40. https://doi.org/10.1109/ICoICT55009.2022.9914889.

[13] Microsoft (2023). Learn Power Platform Power BI: Create key influencers visualizations https://learn.microsoft.com/en-us/power-bi/visuals/power-bi-visualization-influencers?tabs=powerbi-desktop

[14] Sufi, F. K. (2021). AI-Landslide: Software for acquiring hidden insights from global landslide data using Artificial Intelligence. Software Impacts, 10, 100177.

[15] Sufi, F. K. (2022a). AI-GlobalEvents: A Software for analyzing, identifying and explaining global events with Artificial Intelligence. Software Impacts, 11, 100218.

[16] Sufi, F. (2022b). A decision support system for extracting artificial intelligence-driven insights from live twitter feeds on natural disasters. Decision Analytics Journal, 5, 100130.

[17] Sufi, F. K., & Alsulami, M. (2021). Knowledge discovery of global landslides using automated machine learning algorithms. IEEE Access, 9, 131400-131419.