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RESEARCH

Sustainable Development and Green Technologies as a New Dimension of Foreign Policy Co-operation: A Comparative Study of Kazakhstan and the Gulf States

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ABSTRACT

PURPOSE: This paper compares how Kazakhstan and the Gulf nations use green technologies and sustainable development in foreign policy co-operation.

DESIGN/METHODOLOGY/APPROACH: This analytical framework includes descriptive statistics, Prophet time-series forecasting, Principal Component Analysis (PCA), and K-means clustering.

FINDINGS: The analysis divides Kazakhstan and the Gulf Cooperation Council (GCC) into three sustainability performance clusters. Saudi Arabia and Kazakhstan are predicted to further increase CO_2 emissions, while the United Arab Emirates (UAE) and Qatar show flattening patterns in line with their environmental goals.

RESEARCH LIMITATIONS/IMPLICATIONS: The World Sustainability Dataset (www.Kaggle.com) data from 173 countries provides insights into regional sustainability collaboration, although historical coverage and data availability limit the study.

ORIGINALITY/VALUE: This paper introduces a quantitative way of linking foreign policy to sustainability performance. It was one of the first to use machine learning to study Kazakhstan-Gulf state green diplomacy.

KEYWORDS: *Sustainable Development; Foreign Policy; Kazakhstan; Gulf States; Clustering; Forecasting; Renewable Energy; CO_2 Emissions; Green Diplomacy.*

INTRODUCTION

Countries have been forced to change their energy policies, embrace green technologies more quickly, and co-operate strategically with one another as a result of the global push for climate resilience and sustainable development. Partnerships with a sustainable foundation are becoming important foreign policy tools as nations face the dual demands of energy security and decarbonisation. This shift is especially noticeable in areas with abundant natural resources that have historically relied on economies based on hydrocarbons. This dynamic is best shown by the Gulf Cooperation Council (GCC) nations and the Republic of Kazakhstan. Despite having large fossil fuel reserves, these countries need to diversify their energy sources and align their national development paths with international climate goals. The biggest economy in Central Asia, Kazakhstan, has pledged to become carbon neutral by 2060 and has started a number of legislative and regulatory initiatives to support renewable energy. Similar to this, the Gulf states, led by Saudi Arabia and the United Arab Emirates (UAE), have introduced national visions that include sustainability as a key component of economic development (e.g., Saudi Vision 2030, UAE Vision 2050). Despite the political and geographical differences between Kazakhstan and the Gulf states, there are chances for strategic collaboration because of their common interest in a sustainable energy transition. In addition to

offering long-term economic stability, green technologies also provide a forum for regional growth, technological interchange, and diplomatic interaction. Notably, new bilateral agreements between Kazakhstan and the GCC nations highlight an increasing understanding of the benefits of investing in infrastructure, developing a carbon market, and forming collaborations in renewable energy.

This paper examines how green technologies and sustainable development might be used as a new avenue for foreign policy collaboration between Kazakhstan and the Gulf states. The study uses a comparative analytical approach backed by time-series forecasting, clustering algorithms, and economic indicator evaluation. The paper also explores the role of sustainable development and green technologies as a new vector of foreign policy co-operation between Kazakhstan and the Gulf states. By employing a comparative analysis framework supported by clustering algorithms, time-series forecasting, and economic indicator evaluation, the study aims to:

- examine Kazakhstan's and the GCC states' sustainability performance and adoption patterns of green technologies;
- find groups of nations that have similar sustainability features;
- project future trends in CO2 emissions to aid in long-term energy diplomacy;
- encourage both bilateral and multinational green collaboration by suggesting strategic avenues.

The paper adds to the conversation on climate diplomacy and green foreign policy with this multifaceted analysis, providing policy-makers in the Gulf and Central Asia with useful information.

Literature Review

Sustainable development and the development of renewable energy sources are the main focus of the global energy transition agenda. Although Kazakhstan and the GCC are different countries in terms of their political and economic models, they share the potentials and challenges in achieving long-term energy security, diversification of energy options and climate responsibilities. Al-Roubaie (2018) states that integration of sustainable development and green technologies in policy plans are essential in increasing environmental security and economic resilience in Gulf countries, and the use of Islamic ethical values should help build a culture of sustainability. Likewise, Mustafa Omer (2012) talks about the implementation of renewable energy in developing countries and claims that renewable energy technologies represent the key to the long-term energy security and establishment of sustainable development of any country.

Kazakhstan is a transitional economy that has considerably large deposits of fossil fuels and, as part of its national growth agenda, the country has slowly integrated renewable energy technology. A shift in the context of renewable energy adoption has been favourable in view of the recent transformation in their technological ability and financial framework (Benfica and Marques, 2024; Umar and Umeokafor, 2022). Several national plans have been introduced to revolutionise energy

transition and decrease emissions in response to the national commitments to the Paris Agreement (Sabyrbekov *et al.*, 2023). Based on significant estimations, Kazakhstan may significantly accelerate its green transition in the case of policy co-ordination enhancement (Filipović *et al.*, 2024). Despite the apprehension about high levels of fossil fuel sector in Kazakhstan's energy sector (Vakhguelt, 2017; Jianzhong *et al.*, 2018), there is a growing academic consensus that Kazakhstan takes a leadership position in reconstituting energy transformation in the region (Karatairi *et al.*, 2018; Sumer *et al.*, 2019).

International co-operation and geopolitical strategy are different ways of looking at the developments in renewable energy attained by Kazakhstan. Kazakhstan's multi-vector foreign policy and multilateral energy relationships, including its ties with the Belt and Road Initiative (BRI) project led by China (Laruelle, 2018; Sabyrbekov *et al.*, 2023), are significant in the country's endeavours to green modernisation as noted by Zabanova (2023) and Hor (2023). These efforts are also aided by institutional interest in regional institutions such as the Shanghai Cooperation Organisation (SCO) (Baisalbek *et al.*, 2024).

More widely, in terms of Central Asia region, the climate policy landscape is still disjointed (Philavong and Onphanhdala, 2022). Lack of superior international collaboration leads to the low ability of Central Asian states to fulfil their duties according to the Paris Agreement, examined by Sabyrbekov *et al.* (2023). According to Filipović *et al.* (2024), regional integration and energy systems optimisation are also marked with a big opportunity. In the meantime, Iacomelli (2006) and Kurochkin *et al.* (2019) offer a longer-term view of the social and environmental situation, reporting about the renewable energy development in different countries.

The Gulf countries have, however, significantly altered their energy policy, shifting away from hydrocarbon dependence and towards more sustainable frameworks. Oman, Saudi Arabia, and the UAE have all announced national visions to promote investments in sustainable energy technologies (Al-Sarihi and Mansouri, 2022; Al-Maamary *et al.*, 2017). Umar and Umeokafor (2022) state that these goals align with the UN's Sustainable Development Goals (SDGs), particularly in the areas of energy and the environment. In addition, the GCC countries have experienced a lack of investment in green research and development, regulatory lag, and subsidies for fossil fuels (Patlitzianas *et al.*, 2006; Almasri and Narayan, 2021; Doukas *et al.*, 2006). Despite favourable financial and climatic conditions, policy adoption is slow, according to Bhutto *et al.* (2014) and Al-Maamary *et al.* (2017), who review the technological developments and challenges in the GCC energy sector. By relating these concerns to the local political economy, Sim (2023) highlights the importance of institutional resilience and governance reforms in ensuring the sustainability of environmental programmes.

Comparative studies on the adoption of renewable energy in GCC states point at the differences in national agendas and governance frameworks (Patlitzianas *et al.*, 2006; Doukas *et al.*, 2006). Meanwhile, empirical research conducted by Elrahmani *et al.* (2021) and Al-Sarihi and Mansouri

(2022) gives quantitative assessments of how renewable energy has progressed, the efforts to roll out capacity, and direction of capital inflows in the industry. The emerging aspect of sustainable diplomacy is the collaboration of Kazakhstan and the Gulf countries. Academicians such as Baisalbek *et al.* (2024), Zhunussova *et al.* (2020), Vakhguelt (2017), and Gelmanova (2023) believe that knowledge sharing, green investment, and regional decarbonisation through bilateral and multilateral energy initiatives in these regions has the potential to evolve in these regions; academicians are in support of integrated frameworks that integrate initiatives in environmental education, infrastructure, and research in energy.

Although significant progress towards facilitation of the green energy agenda has been measurable within Kazakhstan and GCC states, institutional, political, and economic barriers continue to persist, as envisaged by the literature as a whole (Sampene *et al.*, 2024). To realise long-term sustainable development in the area, collaborative strategies that give front-line strategy co-ordinated investment and policy coherence, as well as energy diplomacy, are important.

Methodology

This study examines sustainability trends and green technology indicators throughout the Republic of Kazakhstan and the Gulf nations using a mixed-methods analytical methodology based on quantitative data mining and machine learning. To find convergence trends and promote strategic foresight in foreign policy collaboration, the methodology combines time-series forecasting, regression modelling, clustering algorithms, and descriptive analytics.

Data Source and Pre-processing

The World Sustainability Dataset (TrueCue, 2021), which offers harmonised annual data for more than 170 nations from 2000 to 2019, serves as the basis for the research. Metrics pertaining to environmental degradation, carbon emissions, renewable energy consumption, socio-economic indicators, and institutional capability are all included in the collection. Data for Kazakhstan and six GCC countries (Saudi Arabia, United Arab Emirates, Qatar, Kuwait, Bahrain and Oman) were extracted for this study. Variables were chosen based on their applicability to energy policy and sustainable development following data cleaning and imputation. The use of renewable energy, CO2 emissions (in million tonnes), adjusted savings from carbon dioxide damage (as a percentage of Gross National Income (GNI)), natural resource rents, the proportion of the population living in cities, the completion rate of primary school, life expectancy, and trade openness are important metrics. To ensure comparability across nations and years, z-score normalisation was used to standardise all numerical markers.

Exploratory and comparative analysis

A series of line plots were created to show the development of key sustainability metrics in order to comprehend past trends. The performance of Kazakhstan and the GCC states was compared using these visualisations (Figures 1-5 in the results section); these showed parallels and discrepancies in energy transitions, environmental challenges, and macro-economic sustainability.

Machine learning: Clustering for strategic grouping

Using averaged indicator values from 2000 to 2019, K-Means clustering was used to find nations with comparable sustainability profiles. The input consisted of eight normalised characteristics. After that, dimensionality reduction and visualisation were accomplished using Principal Component Analysis (PCA). Policy-aligned groupings were revealed by grouping countries into three clusters (Figure 1 in the Strategic Grouping section). Bahrain and the UAE established a progressive group with increased urbanisation and investment in renewables, whereas Kazakhstan, with its higher emissions and reliance on resources, formed its own unique cluster.

Prophet predictive modelling and analytical algorithms

To extrapolate on future CO2 emissions and to enable both strategic analyses of national sustainability pathways, a set of predictive and analytical models were applied. The time-series forecasting, dimensionality reduction and unsupervised learning utilise this methodology to predict emissions, identify structural patterns that go beyond short-term developments, and cluster countries according to a similar emissions path.

Time-series forecasting with Prophet

One of the most important parts of the analysis was the use of Prophet, a powerful prediction algorithm designed by Meta, to produce a decadal (2020-2029) projection of CO2 emissions by country. During the model training process, historical annual emissions data for the period 2000-2019 were used. The time series in each country were fitted separately to get different annual growth patterns and long-term seasonal pattern. The procedure of modelling was based on the steps described in Algorithm 1.

Algorithm 1 Prophet Time-Series Forecasting

```
Input: DataFrame df with columns ds (datetime) and y (target variable)
Initialize model: model ← Prophet()
Fit model: model.fit(df)
Create future periods: future ← model.make_future_dataframe(periods=N)
Forecast: forecast ← model.predict(future)
Plot results:
    model.plot(forecast)
    model.plot_components(forecast)
```

Source: Constructed by authors

Dimensionality reduction via Principal Component Analysis (PCA)

PCA was used to minimise redundancy in the multivariate emissions grid and derive dominating trends across national collections of emissions (see Algorithm 2). The PCA contributed to the reduction of the number of most useful components that allows better visualisation and interpretation of the results regarding clustering.

Algorithm 2 Principal Component Analysis (PCA)

1: **Input:** Numerical dataset with selected features
2: Normalize the features using `StandardScaler`
3: Initialize PCA with desired components: `pca = PCA(n_components = k)`
4: Fit and transform the data: `principal_components = pca.fit_transform(scaled_data)`
5: Extract explained variance ratio: `variance_ratio = pca.explained_variance_ratio_`
6: Visualize principal components using scatter plots or biplots

Source: Constructed by authors

After reducing dimensions, the K-Means Clustering technique was used to assign countries to groups according to the similarity of the behaviour and the trajectory of emissions components (see Algorithm 3). The clustering was useful in the establishment of strategic groups in policy planning and focused intervention.

Algorithm 3 K-Means Clustering

1: **Input:** Dataset with selected input features
2: Normalize the data using a scaling method (e.g., `StandardScaler`)
3: Determine optimal number of clusters K using the Elbow Method
4: Randomly initialize K cluster centroids
5: **repeat**
6: Assign each data point to the nearest centroid
7: Update centroids by computing the mean of all assigned points
8: **until** cluster assignments no longer change (convergence)
9: **Output:** Final cluster labels and centroids
10: Visualize clusters using scatter plots or geographic maps

Source: Constructed by authors

Results

The Republic of Kazakhstan and the Gulf states' sustainability and green technology metrics from 2000 to 2019 are compared in this section. The findings are displayed across figures and are based on information from the World Sustainability Dataset. The consumption trends of renewable energy as a percentage of total final energy use are depicted in Figure 1. The percentage of renewable energy in Kazakhstan is gradually but steadily increasing; this is a sign of early adoption of sustainable practices and initiatives to switch to alternative energy sources. On the other hand, the majority of Gulf governments, such as Saudi Arabia and the UAE maintained low shares of renewable energy during the early 2000s; significant increases only emerged after 2015, most likely as a result of

the implementation of national sustainability agendas. This demonstrates a recent convergence in which sustainable energy technology investment has become a top policy goal for both Kazakhstan and the Gulf states.

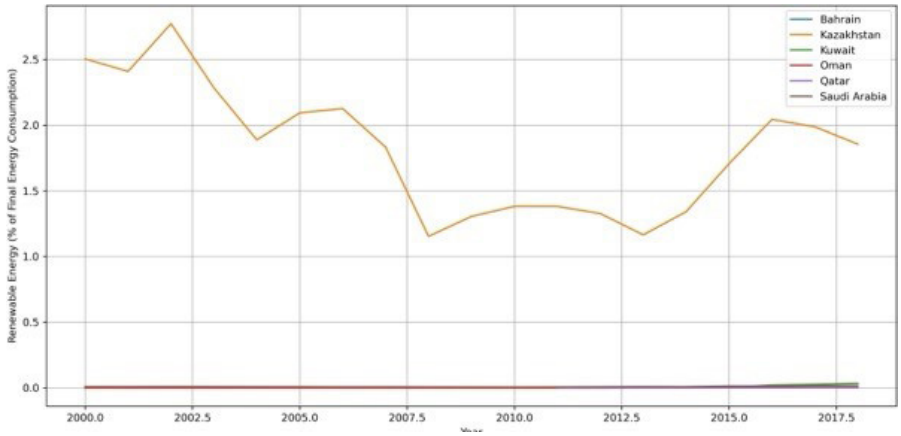

Figure 1: Trends in Renewable Energy Consumption

Source:Constructed by authors based on World Sustainability Dataset (TrueCue, 2021)

The examination of CO_2 emissions expressed in million tonnes in Figure 2 shows notable differences. Among the sample, Saudi Arabia exhibits the greatest emissions, followed by Kazakhstan and the UAE. While Gulf nations continued to have high emissions throughout, a reflection of energy-intensive economies fuelled by the export of fossil fuels, Kazakhstan's emissions climbed gradually before levelling off around 2012. The tendency emphasises how resource dependence has a negative impact on the environment and how important it is for foreign policy co-operation frameworks to include emissions control systems.

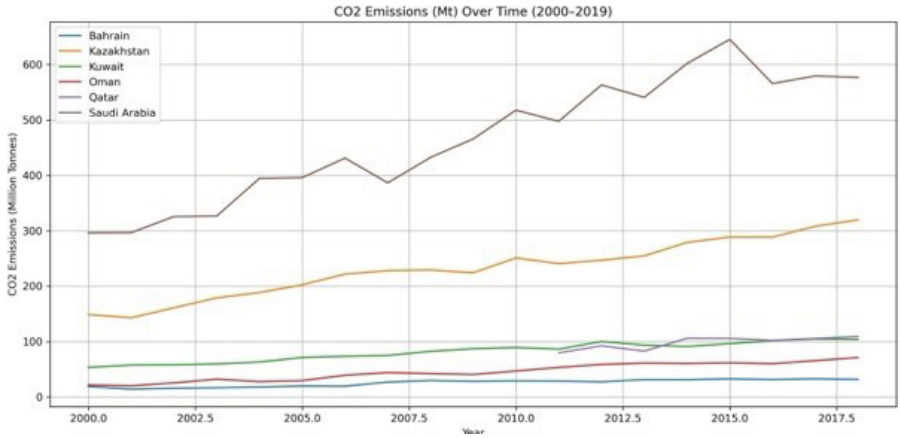

Figure 2: CO_2 Emissions by Country

Source: Constructed by authors based on World Sustainability Dataset (TrueCue, 2021)

As a percentage of Gross National Income (GNI), the economic burden of CO_2 harm is shown in Figure 3. Carbon emissions cause quantifiable economic damages for both Kazakhstan and the Gulf states. This burden falls more heavily on the Gulf states, especially Saudi Arabia and Qatar, in proportion to their higher absolute emissions. Over time, Kazakhstan continues to maintain a more consistent, although still noteworthy, proportion. These findings point to a shared financial incentive for the development of emission-reducing technology and co-operative carbon mitigation plans.

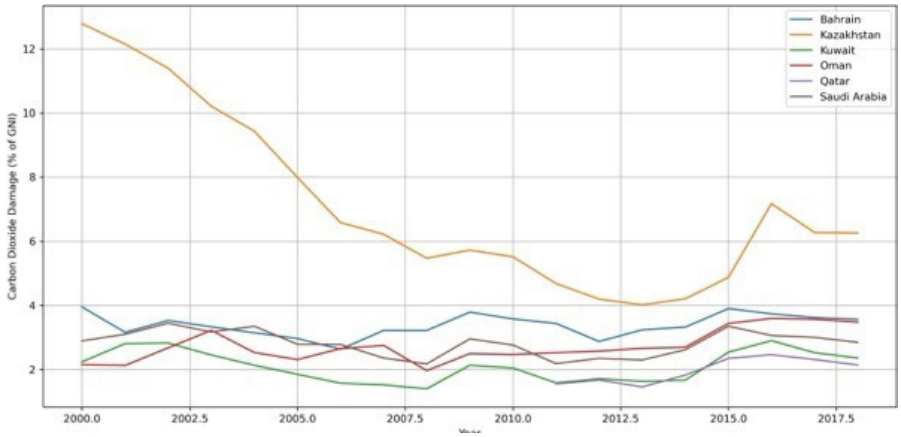

Figure 3: Economic Burden of CO_2 Damage (% of GNI)

Source: Constructed by authors based on World Sustainability Dataset (TrueCue, 2021)

With constant resource depletion across the study time, Figure 4, which focusses on natural resource depletion (as a percentage of GNI), demonstrates Kazakhstan's more severe problem. This demonstrates how dependent the nation is on extractive industries such as mining, oil, and gas. Depletion rates are lower or stable in Gulf nations, possibly as a result of purposeful conservation and diversification measures. In addition to highlighting Kazakhstan's need for structural reforms, the results provide an opportunity for Gulf countries to provide financial and technical assistance for sustainable resource management.

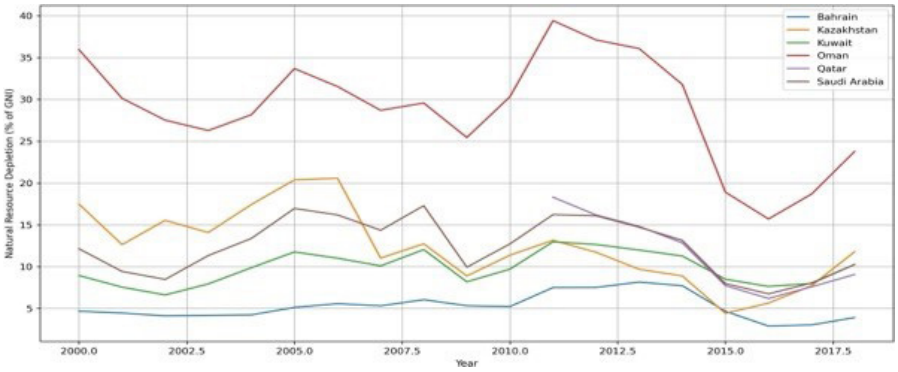

Figure 4: Resource Depletion Trends

Source: Constructed by authors based on World Sustainability Dataset (TrueCue, 2021)

As a comprehensive sustainability indicator, Figure 5 shows adjusted net savings as a proportion of GNI (excluding particulate pollution harm). Kazakhstan is experiencing growing economic trends. As a result of greater investments in long-term development, Gulf nations such as the UAE and Qatar have comparatively higher and more consistent adjusted savings. In addition to providing a route for knowledge and financial transfer from Gulf partners under sustainability-driven co-operation agreements, this disparity highlights the significance of institutional and policy-based initiatives in Kazakhstan.

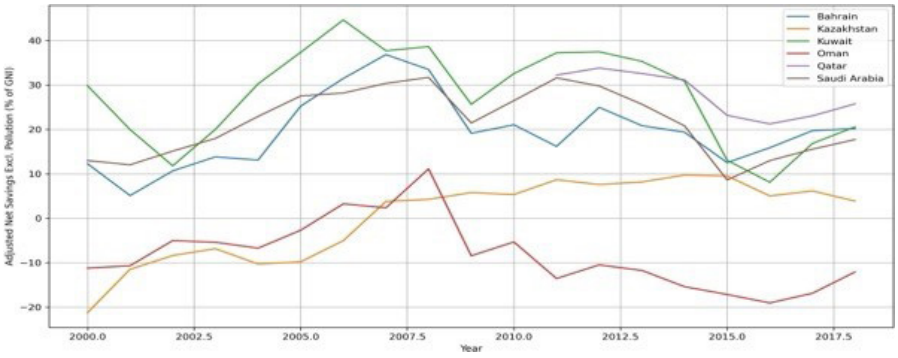

Figure 5: Adjusted Net Savings as a Sustainability Indicator

Source: Constructed by authors based on World Sustainability Dataset (TrueCue, 2021)

When taken as a whole, these numbers offer a quantitative basis for comprehending how Kazakhstan and the Gulf states are becoming more aligned in the areas of green technologies and sustainable development. The research supports the possibility of working together on foreign policy issues based on common economic and environmental concerns.

Strategic Grouping and Forecasting of Sustainability Indicators Clustering Results: Paragraph Explanation

The findings of a K-Means clustering analysis, dividing Kazakhstan and the Gulf states into three separate clusters according to important sustainability metrics such as life expectancy, education, urbanisation, CO2 emissions, renewable energy consumption, and natural resource rents, are shown in Figure 6. A sharper representation of country groups within a sustainability feature space was made possible by the analysis's use of PCA for 2D visualisation.

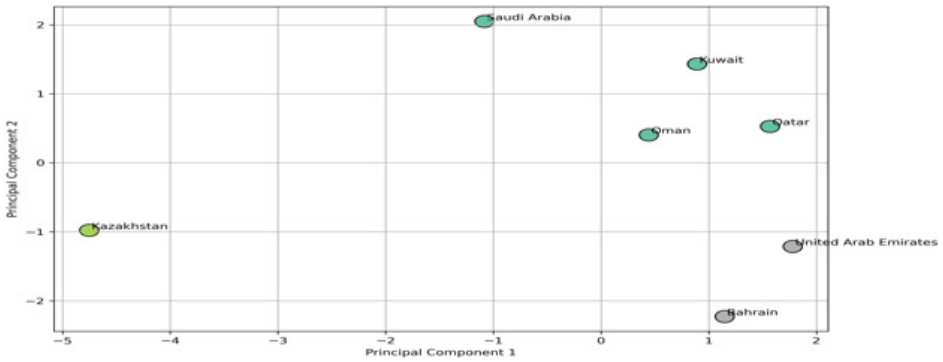

Figure 6: Clustering of Countries by Sustainability Indicators

Source: Constructed by authors based on World Sustainability Dataset (TrueCue, 2021)

Kazakhstan is situated in Cluster 1 and does not share a cluster with any other studied nation. In contrast to the Gulf states, Kazakhstan has higher-than-average CO_2 emissions, more depletion of natural resources, and different trends in urbanisation and education, all of which contribute to its unique sustainability profile. Bahrain and the UAE, which are part of Cluster 0, have more steady economic performance on green metrics, more modern urban infrastructure, and larger investments in renewable energy. The PCA projection explains their close proximity by pointing to their common approaches to adopting renewable energy. Saudi Arabia, Qatar, Oman, and Kuwait are the remaining Gulf nations that make up Cluster 2. These countries share traits such as heavy reliance on fossil fuels, increased emissions, and a sluggish adoption of renewable energy. Their combination points to possible regional collaboration in the shift to greener policies as well as common sustainability challenges. For assessing chances for foreign policy alignment, this clustering technique offers a strategic lens. For example, Kazakhstan may find it easier to develop partnerships with nations in Cluster 0 (Bahrain and the UAE), whereas larger multilateral projects might focus on Cluster 2 in order to transform regional sustainability.

In addition to the K-Means clustering (Figure 6), Figure 7 shows a Hierarchical Clustering Dendrogram that shows how nations are grouped according to their sustainability profiles. The dendrogram calculates the degree of similarity between nations using Euclidean distance and Ward's linkage.

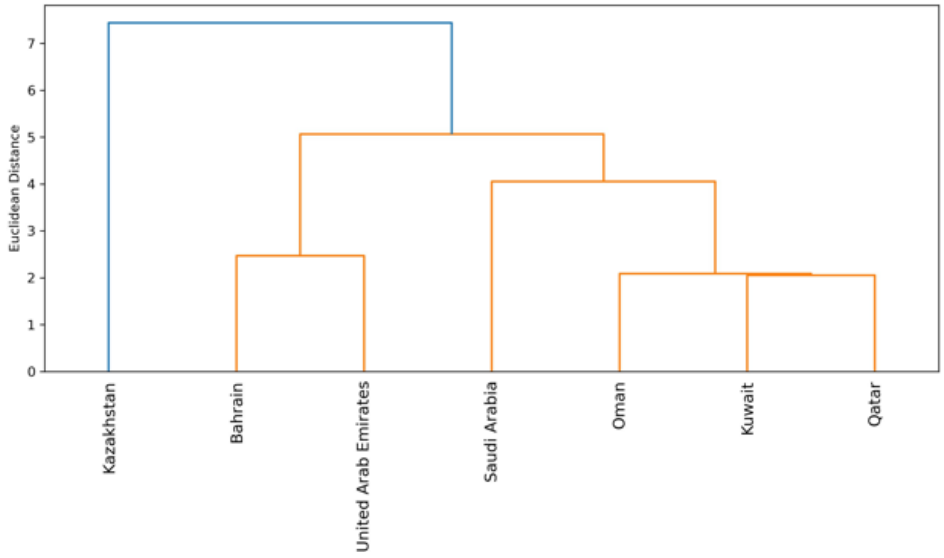

Figure 7: Hierarchical Clustering Dendrogram

Source: Constructed by authors based on World Sustainability Dataset (TrueCue, 2021)

The Prophet model, which was trained on yearly data from 2000 to 2019, is used to project CO_2 emissions for Kazakhstan and six Gulf states for the next ten years (2020-2029) (Figure 8): the projections show a significant difference across nations. Emissions from Saudi Arabia and Kazakhstan are consistently high or marginally rising, indicating a continued reliance on carbon-intensive industries and the urgent need for decarbonisation measures. On the other hand, the emissions trajectories of the UAE and Qatar appear to be flattening or even dropping; this is probably due to recent investments in renewable energy and the incorporation of climate-related policy measures. These distinctions highlight the significance of distinct foreign policy engagement: the UAE and Qatar might act as regional centres for green diplomacy and innovation, while Kazakhstan might profit from outside technical and financial assistance to update its energy infrastructure. In the future, if Kazakhstan implements similar reforms, it can also lay claim to regional leadership in the field of green technologies.

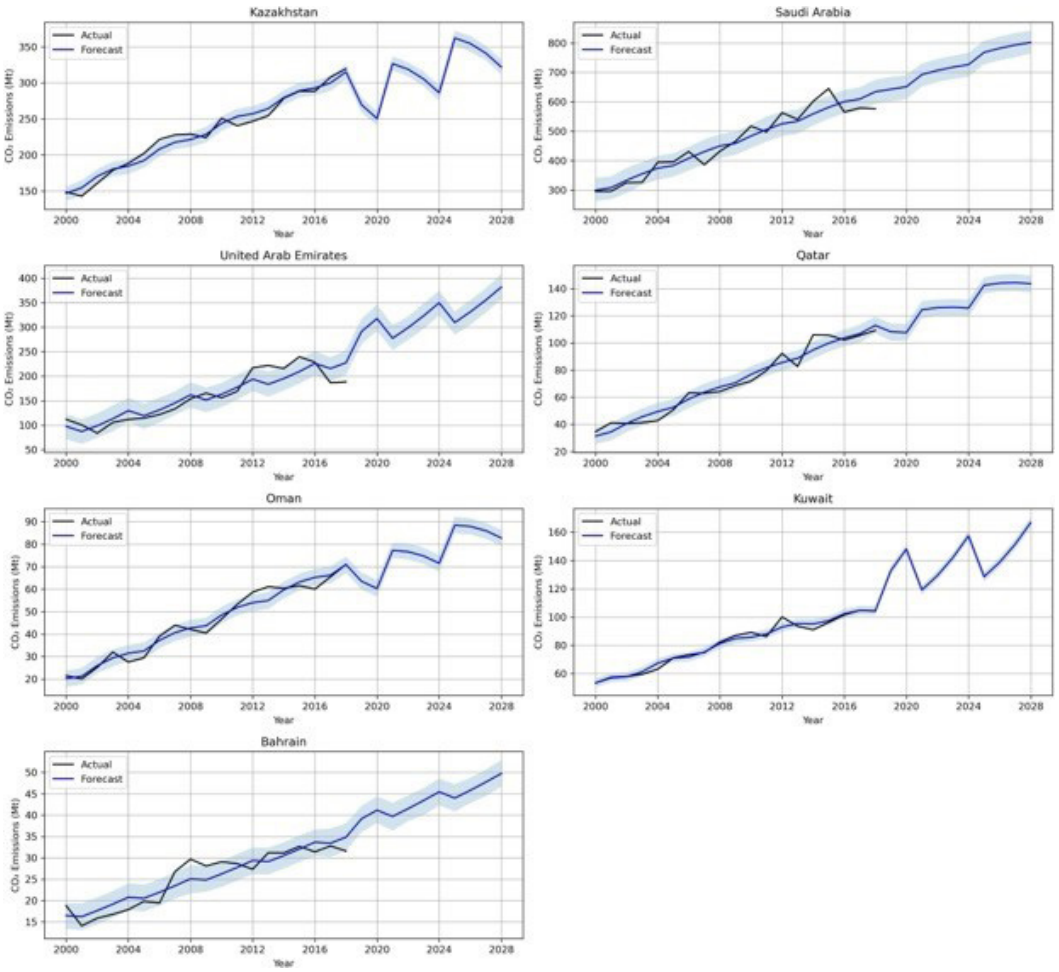

Figure 8: 10-Year CO_2 Emissions Forecasts for Kazakhstan and Gulf State

Source: Constructed by authors based on World Sustainability Dataset (TrueCue, 2021)

CONCLUSIONS

This study examined how green technology and sustainable development are becoming a new avenue for the Republic of Kazakhstan and the Gulf states to collaborate on foreign policy. The study offered empirical insights into these nations' sustainability trajectories by utilising a mixed-methods methodology that combined time-series forecasting, unsupervised machine learning, and comparative analytics. The clustering results showed that Kazakhstan's higher carbon emissions put it in a unique position in terms of sustainability. On the other hand, nations such as Bahrain

and the United Arab Emirates showed more progressive sustainability profiles; these were marked by rising investments in renewable energy, higher life expectancy, and stronger urbanisation. The economies of the other Gulf states (Qatar, Oman, Kuwait, and Saudi Arabia), all relied heavily on fossil fuels, indicating that they face similar regional issues and have room for multilateral collaboration. By providing a graduated similarity map that could facilitate tiered diplomatic and technological engagement methods, the hierarchical clustering dendrogram further verified these groups. Furthermore, the CO_2 emissions projections produced by Prophet showed different future directions. Saudi Arabia and Kazakhstan are expected to continue to have high or rising emissions, requiring reform and foreign policy co-operation. The UAE and Qatar, on the other hand, are predicted to stabilise or lower emissions, underscoring their potential to take the lead in sustainable diplomacy in the region. When taken as a whole, these results offer a data-driven basis for distinguishing foreign policy strategies. While more comprehensive regional frameworks can promote co-operative innovation, green finance, and technology transfer, Kazakhstan and Gulf States can benefit from targeted foreign policy co-operation. Aligning sustainability goals with diplomatic endeavours will be essential for strengthening geopolitical co-operation and quickening the green transition throughout Central Asia and the Gulf as the global climate issue heats up.

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