

CLIMATE CHANGE AND THE KINGDOM OF SAUDI ARABIA: CHALLENGES AND OPPORTUNITIES

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ABSTRACT

This research paper intends to examine the challenges and opportunities faced by the Saudi Arabia owing to climate change. As one of the world's leading oil producers, Saudi Arabia faces unique challenges in addressing climate change. The nation is highly dependent on fossil fuel revenues, which not only contribute significantly to greenhouse gas emissions but also pose risks to long-term economic stability as the world transitions towards greener energy alternatives. Through qualitative research methodologies, including literature reviews and case studies, the study evaluates those rising temperatures, diminishing water resources, and increased frequency of extreme weather events threaten the country's agricultural sectors, water supply, and public health. These environmental impacts underscore the urgency for the Kingdom to diversify its economy and adapt to changing climate patterns. The reliance on oil not only reinforces the need for sustainability initiatives domestically but also raises questions about Saudi Arabia's leadership role in international climate efforts, particularly in the context of its commitments to the Paris Agreement and the Saudi Vision 2030.

Despite these challenges, Saudi Arabia also possesses significant opportunities to leverage its position in the global energy landscape. The Kingdom is actively investing in renewable energy technologies, aiming to generate 50% of its energy from renewable sources by 2030. This shift not only promises to reduce emissions but also to create jobs and foster economic diversification through the development of new industries. Moreover, Saudi Arabia's strategic geographical location offers the potential for solar energy production and wind power, along with its abundant natural resources for carbon capture and storage technologies. However, this research recommends that by capitalizing on these opportunities, the Kingdom can transition towards a

more sustainable economy while playing a pivotal role in regional and global efforts to mitigate climate change. Ultimately, the pursuit of environmental sustainability can align with Saudi Arabia's economic goals, paving the way for a resilient future that balances growth with ecological stewardship.

Keywords: Climate Change, Fossil Fuel Dependence, Renewable Energy, Economic Diversification, Sustainability Initiatives, Paris Agreement, Saudi Vision 2030

INTRODUCTION:

Climate change is an increasingly pressing global issue that significantly impacts nations around the world, and Saudi Arabia is no exception. As a country characterized by its arid climate and reliance on fossil fuels, Saudi Arabia faces unique challenges due to climate change. The Kingdom's economic stability, environmental health, and social well-being are intertwined with changing weather patterns, rising sea levels, and international pressures to reduce greenhouse gas emissions. Despite these challenges, there are also opportunities for Saudi Arabia to lead in innovations for sustainability and eco-friendly initiatives, aligning with its Vision 2030 plan.

One of the principal challenges Saudi Arabia faces as a result of climate change is the intensification of extreme weather events, including prolonged droughts and heatwaves. Studies have shown that the Middle East, including Saudi Arabia, could experience significant temperature increases, potentially exceeding 4°C above pre-industrial levels by the end of the century (Mariotti, Pan, Zeng, & Alessandri, 2012). Such climatic changes threaten water resources, agricultural productivity, and biodiversity, exacerbating already existing issues of water scarcity that the Kingdom grapples with due to its arid conditions (Alotaibi, Baig, Najim, Shah, & Alamri, 2023). The reliance on traditional agricultural methods may no longer be sustainable, requiring a shift to more resilient practices that adapt to changing climatic conditions. In addition to environmental challenges, Saudi Arabia's economic structure poses significant hurdles in addressing climate change. As one of the world's leading oil producers, the Kingdom's economy is heavily dependent on fossil fuel revenues, which contributes substantially to greenhouse gas emissions. Transitioning to a greener economy while maintaining economic stability and growth presents an intricate dilemma for policymakers. However, the Kingdom

recognizes the need for economic diversification as part of its Vision 2030 plan, which aims to reduce dependency on oil and invest in renewable energy and other sustainable sectors (Habibi, 2019). This transition presents an opportunity for rethinking economic models and promoting green technologies.

Renewable energy represents a significant opportunity for Saudi Arabia amid the challenges posed by climate change. The Kingdom has abundant solar and wind resources that can be harnessed for clean energy production. In fact, estimates suggest that Saudi Arabia has the potential to generate over 200 gigawatts (GW) of solar energy alone (Al Zohbi & AlAmri, 2020). By investing in renewable energy technologies, the Kingdom can reduce its carbon footprint, create jobs, and stimulate innovation while also contributing to global sustainability efforts. The government has already invested heavily in large-scale solar projects, such as the Saudi Arabian Renewable Energy Program, which aims to generate 58.7 GW of renewable energy by 2030 (Ghanem & Alamri, 2023).

LITERATURE REVIEW:

Climate change is an imminent threat faced by nations worldwide, and Saudi Arabia is no exception. This oil-rich Kingdom, traditionally reliant on its vast petroleum reserves, faces unique challenges that stem from its arid climate, economic dependence on fossil fuels, and the need for sustainable development. Literature exploring climate change in Saudi Arabia has begun to emerge, emphasizing both the challenges and opportunities for a country seeking to adapt and respond.

One of the significant challenges posed by climate change in Saudi Arabia is the increased frequency of extreme weather events, such as heatwaves and droughts. Al Zawad & Aksakal (2010) emphasize that rising temperatures will exacerbate water scarcity issues in a country where water is already a precious resource. The study shows that by 2050, regions in Saudi Arabia could experience water shortages that threaten agricultural productivity and food security. This challenge requires urgent adaptation measures, including the implementation of advanced irrigation technologies and sustainable water management practices.

In addition to water scarcity, climate change poses serious health risks. According to a study by

Islam, Alharthi, & Alam (2019), increasing temperatures and extreme weather events can lead to a rise in heat-related illnesses and vector-borne diseases. This situation presents a public health challenge that requires innovative health strategies and programs to educate the population about climate-related health risks. The intersection of climate change and public health is an area of growing concern that warrants further research and funding.

Despite these challenges, the Saudi government has recognized the potential opportunities presented by climate change. Vision 2030 emphasizes economic diversification and sustainable development, reflecting a commitment to reducing reliance on oil. In their research, Belaïd & Al Sarihi (2022) highlights how renewable energy initiatives, such as the development of solar and wind energy projects, align with global climate agreements and can drive economic growth while promoting environmental sustainability. Transitioning to a greener economy might stimulate job creation and technological innovation.

Moreover, initiatives like Saudi Arabia's Green Initiative indicate the government's willingness to invest in sustainability. As noted by Al-Gahtani (2024), the initiative aims to plant millions of trees and promote environmental conservation, thereby enhancing biodiversity and combating climate change. These efforts showcase how proactive environmental policies can serve both ecological and economic purposes, deploying the country's resources towards a more sustainable future.

Furthermore, international collaboration is a critical aspect of addressing climate change challenges in Saudi Arabia. Studies by Abubakar & Dano (2020) suggest that international partnerships can help the Kingdom access funding, share technology, and foster knowledge exchange necessary for managing climate change impacts. For instance, joint projects with Gulf Cooperation Council countries could bolster infrastructure resilience and improve disaster response capabilities across the region.

The imperative for sustainability extends to the corporate sector as well. A study by Hashmi & Al-Habib (2013) illustrates how businesses in Saudi Arabia are beginning to adopt sustainable practices that align with the global climate agenda. This shift represents both a challenge and an opportunity, as companies navigate the complexities of change while looking for new markets and services that cater to environmentally conscious consumers. Increasing corporate

responsibility not only enhances a company's reputation but could also ensure long-term profitability.

In short, literature on climate change in Saudi Arabia reveals both significant challenges and promising opportunities. As the Kingdom faces water scarcity, public health risks, and the need for economic diversification, its commitment to sustainability through initiatives like Vision 2030 and its Green Initiative provides a forward-looking roadmap. Through international collaboration and private-sector engagement, Saudi Arabia can navigate its unique challenges and leverage opportunities that arise from climate change, marking a pivotal transition towards a sustainable future.

RESEARCH QUESTIONS:

RQ1: What are the key challenges Saudi Arabia faces regarding climate change?

RQ2: What opportunities can arise from addressing these challenges?

RQ3: How is Saudi Arabia responding to climate crisis?

RESEARCH OBJECTIVES:

- To evaluate the key challenges Saudi Arabia faces regarding climate change
- To assess the opportunities can arise from addressing these challenges
- To investigate Saudi Arabia responding to climate crisis

SIGNIFICANCE OF THE STUDY:

The study of climate change in Saudi Arabia is of paramount importance due to the nation's unique climatic conditions and its role as a leading oil producer. As a country characterized by extreme temperatures, limited freshwater resources, and a heavy dependence on fossil fuel revenues, Saudi Arabia faces significant challenges in addressing the impacts of climate change. Rising temperatures, increasing aridity, and the potential for more severe weather events threaten not only the nation's natural ecosystems but also its economic stability, social structures, and food security. Understanding these dynamics is crucial for developing effective adaptation and mitigation strategies that can safeguard livelihoods, promote sustainable development, and

enhance resilience among vulnerable communities.

However, alongside these challenges lie considerable opportunities for Saudi Arabia to innovate and diversify its economy. The kingdom's Vision 2030 initiative emphasizes the need for a transition towards renewable energy sources, energy efficiency, and sustainable practices, aligning economic growth with environmental protection. Research on climate change can inform policies aimed at harnessing solar and wind energy, investing in green technologies, and nurturing sustainable agriculture. By leveraging its natural resources and investing in human capital, Saudi Arabia can transform the perceived threats of climate change into avenues for economic diversification, job creation, and environmental stewardship. This comprehensive understanding of both challenges and opportunities makes the study of climate change in Saudi Arabia a critical area for researchers, policymakers, and stakeholders aiming to build a sustainable future.

RESEARCH METHODOLOGY:

A qualitative research methodology through wide-ranging literature reviews offers a comprehensive approach to understanding these challenges and the corresponding opportunities for adaptation and mitigation. Through extensive reviews of books, research articles, and journals, scholars have highlighted the multifaceted challenges the Kingdom faces as it grapples with the impacts of climate change.

The qualitative research approach sheds light on the lived experiences of local communities, policymakers, and environmentalists, thus providing a nuanced view of how climate change affects various stakeholders. Researchers employ methods such as interviews, focus groups, and participant observations to capture the socio-cultural implications of environmental shifts. This layered understanding serves not only to inform governmental strategies and public policies but also to engage the broader population in meaningful dialogue about sustainability and adaptation.

An Analysis on Climate Change and Saudi Arabia: Challenges and Opportunities Key Challenges Saudi Arabia faces regarding climate change:

Saudi Arabia, a nation predominantly characterized by its vast deserts and reliance on oil, faces a unique set of challenges regarding climate change. As one of the world's leading oil producers,

the kingdom's economy is heavily dependent on fossil fuels. This reliance not only affects its environment but also poses significant risks to its future sustainability. This section discusses the key challenges Saudi Arabia faces regarding climate change, including water scarcity, extreme temperatures, energy dependence, economic diversification, and environmental degradation.

Water Scarcity

One of the most pressing challenges facing Saudi Arabia is water scarcity. The nation is one of the driest countries in the world, with about 75% of its land classified as desert (Tarawneh & Chowdhury, 2018). Climate change exacerbates this issue, leading to lower rainfall and higher evaporation rates. As the population continues to grow, the demand for water escalates, intensifying competition for this precious resource. The country's reliance on non-renewable aquifers and desalination plants raises both environmental and economic concerns.

Extreme Temperatures

Rising global temperatures pose another significant challenge for Saudi Arabia. Studies indicate that the region is experiencing an increase in both average and extreme temperatures, which can lead to severe heatwaves, impacting public health and food security (AlZohbi, Alzahrany, & Kabir, 2021). The long-standing practice of air conditioning in homes and public buildings, while providing immediate relief from the heat, also leads to increased energy consumption, adding to the country's carbon footprint.

Energy Dependence

Saudi Arabia's socio-economic structure is deeply intertwined with its oil resources. The country heavily relies on fossil fuels not only for economic output but also for energy generation (Kosárová, 2020). As climate change continues to gain global attention, the push for renewable energy sources increases, creating a dilemma for Saudi Arabia. Transitioning from an oil-dependent economy to one based on renewable energy presents both technical and policy challenges, as government initiatives to diversify the energy portfolio must compete with the established oil sector.

Economic Diversification

To address the challenge of climate change, Saudi Arabia has recognized the necessity of economic diversification. The Vision 2030 initiative is a significant step towards reducing the

country's dependence on oil by fostering sectors like tourism, finance, and renewable energy (Habibi, 2019). However, transitioning to a diversified economy requires substantial investments, effective governance, and a commitment to sustainable practices. The challenge lies in balancing these changes while ensuring economic stability for current oil-dependent sectors.

Environmental Degradation

Saudi Arabia's rapid industrialization and urbanization have led to significant environmental degradation, including desertification and air pollution (Alshammry & Muneer, 2023). These environmental issues not only contribute to climate change but also have adverse effects on public health and biodiversity. The need for sustainable urban planning and environmental protection measures is paramount to mitigating these challenges while promoting economic growth.

International Obligations

Saudi Arabia faces pressure from the international community to adhere to environmental agreements, which can be challenging given its economic interests in oil production. The Kingdom is a signatory to the Paris Agreement, committing to reducing greenhouse gas emissions and enhancing carbon capture technology (Raiser, Çalı, & Flachslanđ, 2022). However, the implementation of these commitments requires substantial investments and systemic changes, which can be met with resistance from various stakeholders within the country.

Public Awareness and Education

Raising public awareness regarding the impacts of climate change is crucial for fostering a culture of sustainability in Saudi Arabia. However, there is still a significant gap in climate education, particularly among younger generations (Akinwale, 2022). Enhancing public understanding of climate-related issues and promoting responsible environmental practices are essential for creating a collective response to the challenges posed by climate change.

Technological Development

Investing in technology is fundamental for Saudi Arabia to address climate change challenges. Though the government has made strides in renewable energy projects, such as solar and wind energy (Tlili, 2015), ongoing technological development is necessary to improve efficiency in resource management. Additionally, adopting carbon capture and storage technologies can help mitigate the adverse effects of fossil fuel consumption while ensuring economic vitality.

Opportunities that can arise from addressing these challenges

As one of the world's largest oil-producing nations, Saudi Arabia faces significant challenges posed by climate change. However, in tackling these challenges, the Kingdom has the opportunity to redefine its economic landscape, enhance its global standing, and meet the needs of its citizens. This section of study explores potential opportunities arising from addressing climate change challenges in Saudi Arabia, emphasizing sustainable development, economic diversification, technological innovation, and international collaborations.

Economic Diversification and Sustainability

Saudi Arabia's Vision 2030 underscores the need for economic diversification away from oil dependency (Al-Hayaly, 2022). By investing in renewable energy sources such as solar and wind, the Kingdom can reduce its reliance on fossil fuels. The Global Energy Transformation report by the International Renewable Energy Agency (IRENA, 2019) highlights the potential for significant job creation and economic growth associated with the transition to renewable energy (Gielen et al., 2019). This shift could empower local industries and create a resilient economy aligned with global sustainability goals.

Job Creation and Skill Development

Transitioning to a green economy offers immense job creation potential estimates that green investments could provide millions of jobs globally in sectors ranging from renewable energy to energy efficiency (McLennan, 2022). For Saudi Arabia, this means training a workforce capable of operating within these new industries. Investing in education and vocational training programs can equip Saudis with the necessary skills to thrive in a diversified job market, thus reducing unemployment while addressing climate goals.

Advancement in Technological Innovation

Addressing climate change challenges necessitates innovation in technology and infrastructure. Saudi Arabia has the potential to emerge as a hub for research and development in clean technology. The establishment of funds focused on sustainability, such as the Saudi Green Initiative, encourages private and public sector investment in innovative solutions (Ghanem & Alamri, 2023). This can lead to the development of cutting-edge technologies that make energy production and consumption more efficient and sustainable.

Enhanced Global Reputation

By taking proactive steps toward sustainable development, Saudi Arabia can enhance its global reputation as a leader in the energy transition. Participation in international agreements such as the Paris Agreement can demonstrate the Kingdom's commitment to addressing climate issues. This commitment not only aligns with global trends but also enhances the country's diplomatic relationships and can attract foreign investments (Kukic, 2020). The credibility derived from such engagements can foster a more robust international image.

Tourism and Eco-Friendly Initiatives

The global tourism market increasingly prioritizes sustainability, leading to a growing interest in eco-friendly travel options. Saudi Arabia's rich cultural heritage and natural landscapes present opportunities for sustainable tourism (Alyusuf, 2021). By promoting eco-tourism initiatives and green travel options, the Kingdom can attract international tourists who value sustainability, generating revenue while showcasing its commitment to climate action.

Public Health Benefits

Climate change has direct implications for public health, particularly regarding air quality and extreme weather conditions (Amran, Amran, Alyousef, & Alabduljabbar, 2020). By reducing carbon emissions and mitigating climate change, Saudi Arabia can improve overall public health outcomes. Cleaner air and better living conditions can lead to substantial healthcare savings and a healthier workforce, enhancing productivity and quality of life for its citizens.

Investment in Water Conservation Technologies

Water scarcity is a critical issue in arid regions like Saudi Arabia. The challenges posed by climate change exacerbate this issue (Singh & Chudasama, 2021). By investing in innovative water conservation technologies, the Kingdom can enhance its water security. Advanced desalination techniques, water recycling, and sustainable agricultural practices can not only address immediate water scarcity but can also promote long-term ecological balance and sustainability.

Mobilizing Financial Resources

Addressing climate change presents an opportunity for Saudi Arabia to leverage financial resources more effectively. Green financing mechanisms, such as green bonds, allow for

investment in sustainable projects while attracting environmentally-conscious investors (Versal & Sholoiko, 2022). Such financial innovations can support the country's transition to a green economy, promoting accountability and transparency in funding climate initiatives.

Saudi Arabia responses to Climate crisis

Saudi Arabia, one of the world's largest oil producers, finds itself at a critical juncture concerning climate change. The nation's economic dependency on fossil fuels has historically positioned it as a significant contributor to carbon emissions. However, recent shifts in domestic and international pressures have prompted the Kingdom to reassess its strategies regarding environmental sustainability. This section of research paper explores how Saudi Arabia is responding to the climate crisis through policy adaptation, renewable energy initiatives, and international collaborations.

VISION 2030: A PATHWAY TO SUSTAINABILITY

In 2016, Saudi Arabia launched its Vision 2030 program, which aims to diversify the economy away from oil dependency and promote sustainability (Habibi, 2019). As part of this initiative, the Kingdom has committed to cutting greenhouse gas emissions, increasing the share of renewable energy in its energy mix, and enhancing energy efficiency. Vision 2030 represents a broader recognition of the need to address climate change, making a remarkable pivot from its traditional economic model towards a more sustainable framework.

Renewable Energy Initiatives

Saudi Arabia is investing heavily in renewable energy sources, particularly solar and wind. The National Renewable Energy Program aims to generate 58.7 GW of renewable energy by 2030 (Tlili, 2015). This ambitious target includes the construction of the world's largest solar plant, the Sakaka PV IPP project, and a focus on harnessing wind energy in regions with high potential. By transitioning towards renewables, Saudi Arabia is making strides in reducing its carbon footprint while creating new jobs in emerging sectors.

Carbon Capture Technology

In tandem with renewable initiatives, Saudi Arabia is exploring carbon capture, utilization, and storage (CCUS) technologies. These technologies are designed to capture up to 80-90% of CO₂

emissions from power plants and industrial sources (Lau, Ramakrishna, Zhang, & Radhamani, 2021). The Kingdom has already initiated several pilot projects, including the Uthmaniyah CO₂-EOR project, which demonstrates its commitment to mitigating greenhouse gas emissions while maintaining its petroleum industry operations.

International Partnerships and Agreements

Saudi Arabia recognizes that climate change is a global issue that requires collective action. The Kingdom has pledged support for the Paris Agreement, committing to targets that align with global efforts to limit temperature rises (Raiser, Çalı, & Flachslan, 2022). Additionally, it has engaged in collaborative projects with various nations to enhance environmental sustainability, including partnerships aimed at developing green technology and sharing best practices.

Greening the Oil Industry

The Kingdom's approach to addressing climate change also includes efforts to "green" its oil industry. The Saudi Aramco Sustainability Report outlines initiatives aimed at reducing the environmental impact of oil extraction and refining processes (Mirzayev, 2022). These initiatives focus on reducing methane emissions, improving water management, and promoting biodiversity in areas surrounding oil fields, showcasing the company's commitment to sustainable practices within the fossil fuel sector.

Local Environmental Initiatives

In addition to large-scale projects, local environmental initiatives are crucial for addressing the climate crisis. The 'Green Saudi Initiative,' launched in 2021, emphasizes reforestation and preservation of natural ecosystems (Khayat, Felemban, Altowairqi, & Aljahdali, 2023). This program seeks to plant billions of trees and reduce carbon footprints at the community level, further integrating sustainability into the national lifestyle.

Economic Diversification and Green Investment

Transitioning to a sustainable economy requires substantial financial investment and innovation. Saudi Arabia is actively seeking to attract foreign and domestic investments in green technologies. The Green Investment Strategy, part of Vision 2030, promotes sectors such as renewable energy, and sustainable agriculture, aiming for a more resilient economy (Ghanem & Alamri, 2023). By generating green jobs and fostering technological innovation, the Kingdom

aspires to lead the region in sustainable investment initiatives.

CONCLUSION AND RECOMMENDATIONS:

Climate change is increasingly recognized as one of the most pressing global issues of our time, with far-reaching implications for countries around the world. For Saudi Arabia, a nation heavily reliant on oil exports, the threats posed by climate change are particularly acute. Rising temperatures, shrinking water resources, and extreme weather events threaten not only the natural environment but also the economic infrastructure that forms the backbone of the Saudi economy. However, amidst these challenges lie opportunities for innovation, diversification, and leadership in sustainable practices that could redefine the Kingdom's future.

One of the most significant challenges Saudi Arabia faces is its vulnerability to water scarcity and extreme heat. The Kingdom is located in one of the world's driest regions, and climate models predict that rising temperatures will exacerbate water shortages. This situation poses serious risks to agriculture, health, and overall quality of life. As the temperature increases, traditional farming practices may become unsustainable, necessitating the urgent adoption of water-efficient technologies and alternative agricultural practices, including the integration of desalination and hydroponics.

Economically, the reliance on oil exports exposes Saudi Arabia to the risks of fluctuating oil prices and changing global energy trends. As international pressure to transition to renewable energy sources intensifies, the Kingdom faces a unique challenge in maintaining its economic stability while diversifying its energy portfolio. The Vision 2030 initiative outlines ambitious plans to reduce dependence on oil and invest in renewable energy, with a particular focus on solar and wind energy. This shift not only signals a response to climate concerns but also positions Saudi Arabia to potentially become a leader in the global renewable energy market, creating jobs and fostering innovation in technology.

The youth demographic of Saudi Arabia presents a unique opportunity for addressing climate change. With over 60% of the population under the age of 30, there is significant potential for engaging young people in sustainability initiatives and environmental stewardship. By investing in education and training programs focused on green technologies and sustainability practices,

the Kingdom can harness the creativity and innovation of its youth to tackle climate challenges. Empowering young Saudis to take part in climate action can also drive community engagement and foster a culture of sustainability that extends beyond government policies.

In brief, while Saudi Arabia faces considerable challenges due to climate change, these obstacles also present profound opportunities for transformation. By embracing technology and investing in sustainable practices, the Kingdom can not only protect its economic interests but also take a proactive role in the global fight against climate change. By positioning itself as a leader in renewable energy and empowering its youth, Saudi Arabia has the potential to create a resilient and sustainable future—turning the challenges of climate change into a catalyst for progress and prosperity.

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