Assessing the Economic and Energy Sector Vulnerabilities of Iran to Global Climate Change Response Measures

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The objective of this study is to investigate the economic vulnerabilities of Iran's energy sector using a system dynamics modeling approach, with a particular emphasis on how global climate change response measures impact the country's energy industry. Due to its heavy reliance on fossil fuels, Iran's economy is highly susceptible to changes in global oil demand. This study seeks to evaluate the potential economic consequences that international climate policies could have on the country.

The study is based on the socio-economic pathways (SSPs) established by the Intergovernmental Panel on Climate Change (IPCC), which outline different levels of climate action and the resulting economic outcomes. The research encompasses five different SSPs, ranging from aggressive climate mitigation strategies (SSP1-1.9) to fossil-fuel-dependent development trajectories (SSP5-baseline). The study examines a wide range of potential future outcomes for Iran's energy-economy system, considering various scenarios that consider energy demand, economic growth, and climate policy implementation.

The core of the analysis centers on understanding how Iran’s economy, which is heavily reliant on oil exports, could be affected by global reductions in fossil fuel consumption, which are expected as part of the global effort to reduce greenhouse gas emissions. The research assesses the projected oil price fluctuations and subsequent impacts on Iran’s oil production in each climate scenario. It also examines the potential decline in Iran’s oil revenues and its broader economic consequences, including impacts on gross domestic product (GDP), energy demand, and population growth.

In the most stringent scenarios, such as SSP1-1.9 and SSP1-2.6, which prioritize sustainability and rapid emission reductions, Iran's oil production is projected to face sharp declines. By 2050, the cumulative economic damage from implementing global climate change policies under SSP1-1.9 could amount to approximately $1.26 trillion. This scenario represents a future where the global transition to renewable energy severely restricts the demand for fossil fuels, including oil, thus reducing the economic opportunities for oil-exporting countries like Iran. Similarly, the SSP1-2.6 scenario, although less stringent, still predicts significant economic losses for Iran, with potential damages reaching $738 billion by 2050.

Conversely, under more moderate or fossil-fuel-friendly scenarios like SSP3-baseline and SSP5-baseline, the economic impacts on Iran are less severe. These scenarios reflect a future where global energy demand continues to grow, albeit at a slower pace, allowing Iran to maintain a more robust oil export market for a longer period. The SSP3-baseline scenario, characterized by regional competition and inequality, forecasts economic damages amounting to $187 billion by 2050, while the SSP5-baseline scenario, which assumes continued reliance on fossil fuels, estimates losses of around $739 billion.

Interestingly, the SSP2-4.5 scenario, which balances climate action and economic growth, suggests that Iran could experience moderate economic growth, even surpassing the scenario of business as usual. This indicates that with careful management and strategic investments in low-carbon technologies and renewable energy, Iran could mitigate some of the negative effects of global climate policies on its economy. The findings stress the importance of reducing the country's

dependence on oil exports and transitioning towards a more diversified economy that is less vulnerable to the fluctuations in the global oil market.

In addition to examining the economic damage in terms of lost oil revenue, the research delves into the broader energy sector, analyzing changes in energy demand, gas production, and oil market dynamics. Iran's gas production is expected to increase in several scenarios, especially those involving a transition from high-carbon fossil fuels to cleaner alternatives like natural gas. The SSP1-1.9 scenario, in particular, sees significant growth in gas production, as natural gas serves as a key energy source in the move towards decarbonization. However, even in these optimistic scenarios, Iran's reliance on fossil fuel exports presents challenges, as the global push for renewable energy continues to erode demand for oil.

The study's findings underscore the urgency for Iran to take proactive steps to diversify its economy, moving away from oil dependency, and investing in renewable energy infrastructure. By fostering a low-carbon economy, Iran can position itself more favorably in a future characterized by strict global climate policies. Furthermore, the research highlights the significance of managing the cross-border effects of climate change response measures, particularly for developing economies with large fossil fuel reserves.

In conclusion, this paper contributes to the growing body of literature on the cross-border economic impacts of climate change mitigation policies. It offers valuable insights into how stringent global climate actions could reshape Iran's economic landscape, particularly by influencing its oil-based revenue streams. The research advocates for integrating sustainable development strategies into national policy to buffer the adverse effects of declining fossil fuel demand, emphasizing that a balanced approach to climate change mitigation could offer Iran opportunities for economic resilience and growth in a low-carbon future.

Keywords: Climate Change, System Dynamics, Energy Economics, Oil Market, Fossil Fuels, Socio-Economic Pathways, Iran, Climate Mitigation, Cross-Border Impacts, Renewable Energy Transition