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Developing a Foundational Framework for Emission Policy Design to Mitigate CO_2 Emission in Iran: A Case Study of an Empirical Approach to Guiding Decision-Makers in Iran Using Simplified DICE Models

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Highlights

- Despite being one of the top global emitters of greenhouse gases (GHGs), Iran has not yet taken serious steps to reduce its emissions, even though doing so is inevitable.
- The primary challenge for decision-makers is to establish an analytical framework. This framework must guide them toward the necessary strategies, forecast the outcomes of their actions against targeted goals, and finally, monitor their progress.
- Among all integrated assessment models (IAMs), the 2023 simplified DICE model was selected as the basis for analysis. The evaluation of four scenarios revealed positive outcomes for CO_2 mitigation, while also indicating that GDP and the economy would benefit from both the mitigation efforts and the resulting decrease in emissions.

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Abstract

Climate change is a global issue, driven largely by greenhouse gas emissions, with carbon dioxide (CO_2) being the most significant contributor. As one of the top ten emitters globally, Iran faces unique challenges in reducing its CO_2 emissions due to economic sanctions, data gaps, and limited experience with climate policy. To help guide decision-makers, this study uses the simplified dynamic integrated climate and economy (DICE) model—a widely accepted tool for analyzing climate and economic interactions—to evaluate different emission reduction strategies. These strategies primarily include carbon pricing, investment in renewables to mitigate emission growth, and improving energy efficiency. The results indicate that such policies can positively impact gross domestic product (GDP), temperature stabilization, and emission levels. This research provides the first numerical framework tailored to Iran's specific context, offering practical insights for policymakers. Key policy implications include the necessity of overcoming sanctions to facilitate investment and technology absorption, improving data collection to refine future analyses, and adopting cost-effective measures that balance economic growth with environmental sustainability.

Keywords: Emission reduction policies, Mitigation strategies for CO_2 emission reduction, Simplified DICE model, Environmental and climate strategies, Environmental economic analysis

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1. Introduction

Over the past century, the concentration of greenhouse gases (GHGs) in the atmosphere has increased dramatically. This rise, largely driven by human activity, has led to significant global temperature increases and the phenomenon of global warming. Major emission sources include deforestation from land-use changes, the burning of fossil fuels for energy and transportation, and agricultural practices such as livestock farming, rice cultivation, and crop residue burning. Additionally, wetlands, industrial operations, and urban activities like construction and waste management are also significant contributors (IPCC, 2023).

The role of carbon dioxide (CO_2) as a key factor in atmospheric changes was identified in the 1950s through infrared absorption studies. Subsequent research has shown that other gases, including methane (CH_4), nitrous oxide (N_2O), and chlorofluorocarbons (CFCs), are also critical drivers of global warming and climate change (Ramachandra et al., 2015). Among these, CO_2 is the most significant, accounting for approximately 77% of global emissions measured in CO_2 equivalents, which underscores its central role in international climate discussions (Solomo et al., 2007).

Since climate change was acknowledged as a major global threat, numerous international initiatives have been launched to address it. These efforts originated with the first World Climate Conference in 1979 and evolved through milestones like the Paris Agreement. However, the international community has yet to achieve a unified, fair, and well-coordinated response. Even among OECD member countries, climate policies often shift and lack consistency (Michaelowa et al., 2019).

Gupta (2010) provides an in-depth analysis of the last 30 years of international climate policy, dividing it into five phases. The study begins with the pre-1990 era, proceeds through the adoption of the Climate Change Convention and the Kyoto Protocol—including the U.S. withdrawal and its eventual implementation—and concludes with the post-2008 period following the global financial crisis. The author highlights a growing shift toward alternative approaches, such as nationally appropriate mitigation actions (NAMAs) for developing countries, efforts to reduce emissions from deforestation and forest degradation (REDD+), and research into geoengineering. Beyond formal negotiations, the study also emphasizes the importance of sub-national climate initiatives, climate-related litigation, and the expanding biofuel industry.

A crucial aspect of developing subnational policies is identifying a country's most effective emission reduction strategies, which requires establishing a fair and achievable target within both global and regional contexts. The main goal of this study is to provide a foundational framework for designing emission reduction policies in Iran. Specifically, we aim to equip decision-makers with a cost-benefit analysis tool based on internationally recognized models like the simplified dynamic integrated climate and economy (DICE) model. By evaluating various scenarios, this research seeks to guide Iran in achieving its emission reduction targets while considering its unique socio-economic and environmental context. This approach not only addresses Iran's immediate challenges but also lays the groundwork for more advanced future analyses.

We hypothesize that:

1. Carbon pricing mechanisms (e.g., a carbon tax) will lead to a gradual reduction in CO_2 emissions, despite short-term economic costs.

2. Investment in renewable energy and energy efficiency improvements will yield both emission reductions and positive economic impacts, such as gross domestic product (GDP) growth.
3. Despite its limitations, the simplified DICE model can serve as a foundational tool for designing emission reduction policies tailored to Iran's unique economic and environmental context.

By testing these propositions, this research aims to provide actionable insights for policymakers and establish a quantitative basis for future climate policy development in Iran.

Regarding Iran, Asadollahi et al. (2024) have thoroughly investigated the challenges of implementing carbon emission mitigation policies. They conclude that the most significant challenge is the lack of a strategic foundation and a governing model, which prevents effective policymaking in this sector. To address this, we have chosen to apply a globally accepted model to derive appropriate strategies. Among all models reviewed (as mentioned in Table 3 of this article), the DICE model was selected due to its global acceptance and the specific benefits outlined in our research methodology. A key advantage of the DICE model is that, while being an accredited tool, it has a medium complexity level and can be used in a simplified mode. This simplified application allows users to obtain results without requiring granular, sectorally-divided data. This is particularly suitable for economies like Iran, which, due to sanctions, is often reluctant to disclose detailed economic data and suffers from a general lack of data clarity across various economic and emissions sectors.

Iran's sanctions, data gaps, and lack of climate policy experience motivated the use of a straightforward model like DICE for policymakers unfamiliar with complex climate-economic tools. Supporting this approach, Asadollahi & Hajian (2021) suggest that while more effective policies often increase complexity, simpler models can serve as an entry point for subnational regions beginning their emission reduction efforts. These basic models enable regions to develop initial strategies, which can be refined as they gain experience and resources. This approach acknowledges the challenges faced by newcomers and emphasizes starting with practical, manageable strategies to lay the groundwork for more advanced measures in the future.

This paper is organized as follows: First, we review global efforts to address climate change and highlight Iran's specific challenges and commitments under international agreements. Next, we outline the research objectives and theoretical foundations. We then describe the methodology, including the selection of the simplified DICE model and the data used. Subsequently, we present and discuss the findings, focusing on their policy implications. Finally, we conclude with recommendations for future research and actionable policy suggestions.

2. Research objectives

The primary goal of this study is to establish the first foundational framework for Iran that integrates data, analysis, and internationally accepted climate models. This framework is designed to help policymakers create effective CO_2 reduction strategies based on the stated hypotheses. It will provide a clear, cost-benefit-driven understanding of how various policies can impact Iran's economy, temperature levels, and emission rates. By utilizing accredited integrated assessment models (IAMs) like the simplified DICE model, this study innovates by addressing Iran's unique challenges—such as economic sanctions, data gaps, and limited climate policy experience—through an accessible and practical tool. This approach not only delivers actionable insights for emission reduction but also establishes a foundation for future refinements, empowering decision-makers to take meaningful steps toward balancing economic growth with environmental sustainability.

3. Literature review

3.1. The history of endeavors

The history of global efforts to reduce greenhouse gas emissions can be divided into five key phases: (1) the period before 1990, (2) the events leading to the adoption of the Climate Change Convention, (3) the era of the Kyoto Protocol, (4) the phase following the Protocol's implementation, and (5) the post-2008 period, which coincided with the global financial crisis (Gupta, 2010).

Since 2008, a series of climate summits have played a crucial role in shaping the global response to climate challenges. Key events include:

1. **COP 15, Copenhagen (2009):** This summit aimed to establish a legally binding agreement to replace the Kyoto Protocol. However, the outcome was the non-binding Copenhagen Accord, which emphasized voluntary emission reduction targets.
2. **COP 21, Paris (2015):** A significant turning point, the Paris Agreement committed nations to limit global warming to well below 2°C, pursuing efforts towards 1.5°C. It introduced nationally determined contributions as a structured framework for national climate action.
3. **COP 24, Katowice (2018):** This conference produced the "Katowice Rulebook," a set of detailed guidelines for implementing the Paris Agreement, including frameworks for transparency and standardized reporting.
4. **COP 26, Glasgow (2021):** Countries pledged to reduce coal consumption, lower methane emissions, and increase financial support for climate adaptation. However, these commitments were insufficient to secure the 1.5°C target.
5. **COP 28, Dubai (2023):** A key focus was the first global stocktake, which underscored the urgent need to cut emissions by 43% by 2030. Major outcomes included establishing a loss and damage fund and boosting climate finance.

Since the Paris Agreement, geopolitical shifts, such as the U.S. withdrawal, have redirected focus toward subnational, national, and individual responsibilities in reducing emissions.

Baatz (2014) argues that while individuals contribute to climate change, their moral obligation to reduce emissions is not fully explored. The analysis suggests that individuals are not always compelled to reduce their emissions to a "fair share" due to their reliance on carbon-intensive systems. Instead, they hold a Kantian imperfect duty to mitigate emissions as reasonably expected and to advocate for stronger government climate policies.

Parag & Fawcett (2014) highlight personal carbon trading (PCT) as an innovative policy approach designed to enhance the efficiency of emission reduction frameworks. This strategy aims to fundamentally transform how carbon emissions are managed and regulated to strengthen the impact of mitigation initiatives.

3.2. Global situation in GHG emission

This study provides an in-depth analysis of global greenhouse gas emissions from 1970 to 2022, focusing on the world's largest emitters: the United States, China, India, Russia, Brazil, Indonesia, Japan, Iran, Mexico, and Saudi Arabia. Collectively, these nations account for approximately 64% of total GHG emissions. The research evaluates the impact of major economic sectors—including industry, energy, agriculture, and transportation—on global emission trends (Filonchyk, Peterson, Yan, et al., 2024).

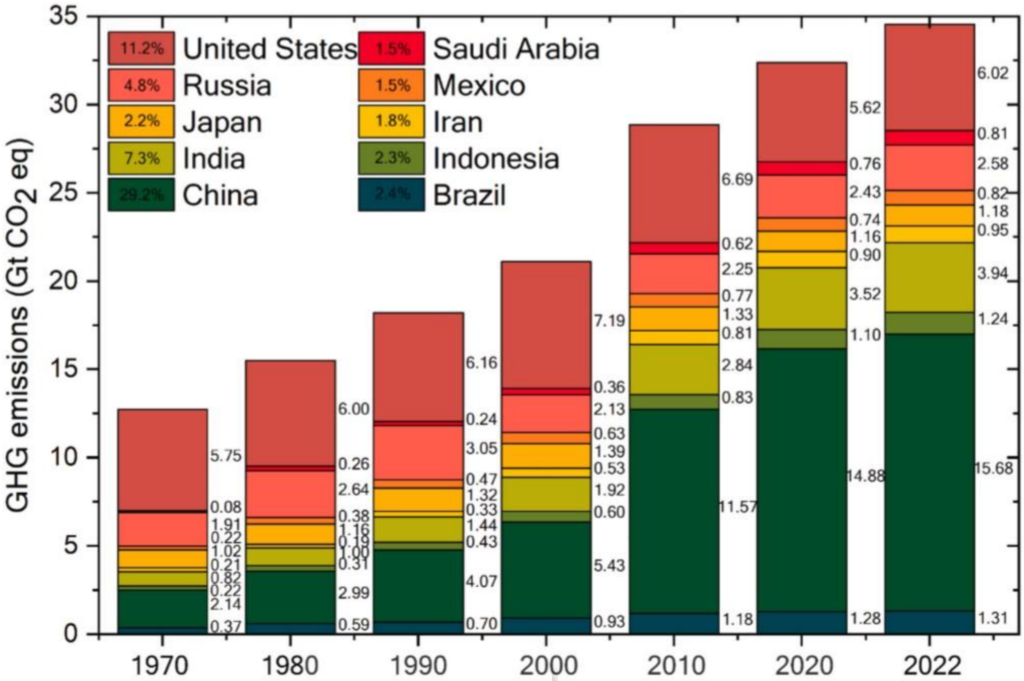

Figure 1

GHG emissions in different countries from 1970 to 2022, indicating the share of each top-ranked source (Ritchie et al., 2020)

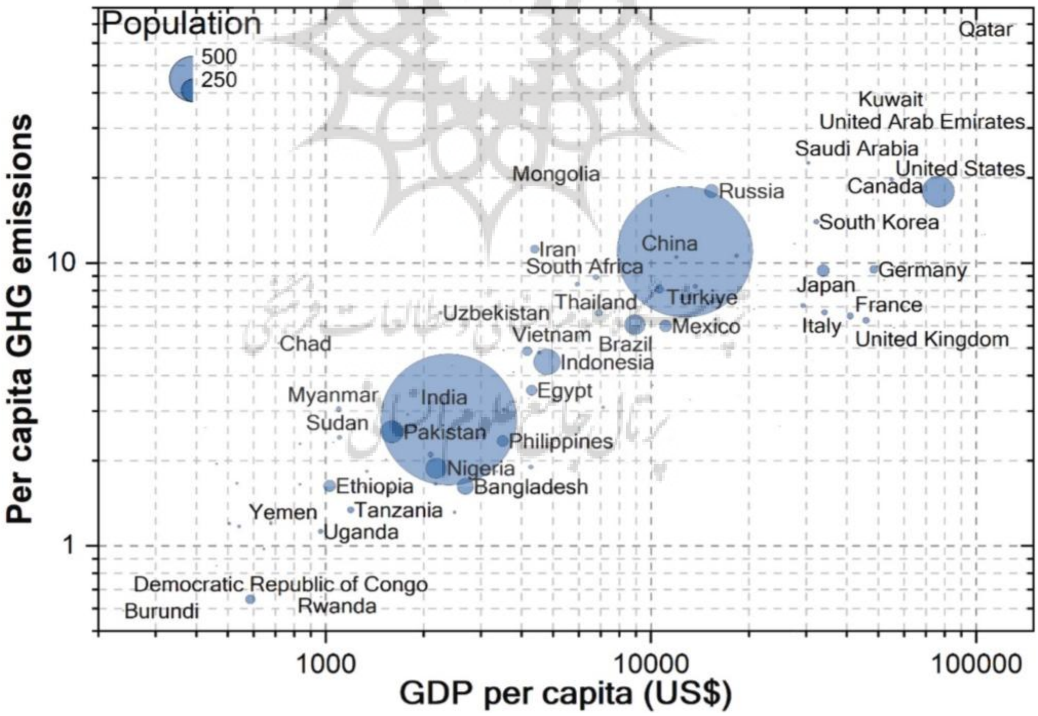

Figure 1

The impact of economic growth on GHG–GDP and GHG relationship per capita in different countries (Filonchyk, Peterson, Zhang et al., 2024)

3.3. Iran situation and undertakings under climate change regimes

According to an IEA publication (2024), Iran ranks first in the Middle East and sixth globally for greenhouse gas emissions when measured by the CO_2 index. Although Iran has signed the Paris Agreement, it has not yet ratified it. The country's commitments to reducing GHG emissions are conditional, heavily relying on international financial and technological assistance.

Rank	Country/Region	Mt CO2
-	**World**	**34116.781**
4	Russia	1623.228
5	Japan	973.667
6	**Iran**	**696.371**
7	Indonesia	651.671
8	Germany	612.004

Figure 3

Iran's World Ranking in CO_2 Emissions (IEA PUBLICATION, 2024)

Iran has emphasized that international cooperation, particularly financial aid, is critical for effectively addressing climate change. Domestically, the country has pursued strategies to improve energy efficiency and expand renewable energy projects. However, progress has been hindered by significant obstacles. Economic sanctions have severely hampered investment in clean energy infrastructure, restricted access to advanced technologies, and delayed the modernization of industrial processes.

According to Ghadaksaz & Saboohi (2020), the limitations on technology transfer and international financial aid during the strict economic sanctions from 2011 to 2015 exacerbated Iran's challenges. The authors contend that with adequate technical and financial support, Iran would be in a stronger position to fulfill its commitments under the Paris Agreement, aligning with its national goals to reduce energy intensity.

3.4. Fair GHG reduction

Contemporary discourse on emission policies has significantly shifted toward the governance and regulation of mitigation efforts, emphasizing the crucial role of individual cooperation. A central question that must be addressed for individuals is, "What constitutes a fair reduction quota and its associated cost?" (Asadollahi et al., 2024).

Ridgley (1996) introduces a framework for assessing the relative responsibilities of regions and individual countries in reducing greenhouse gas emissions. The study stresses that accountability must be rooted in equity, incorporating all equity principles supported by stakeholders. Since each principle offers a distinct perspective on responsibility—often leading to conflicting recommendations—the research investigates the use of multicriteria decision-making techniques to develop balanced solutions. A methodology is proposed that combines various approaches to achieve equitable outcomes. This framework is demonstrated using 11 equity indicators and a multi-goal programming model to create a balanced accountability profile for 11 multinational regions.

Rank	Country/Region	Mt CO2
-	**Middle East**	**1092.345**
1	**Iran**	**696.371**
2	Saudi Arabia	532.875
3	United Arab Emirates	173.642
4	Iraq	170.187
5	Kuwait	94.134

Figure 4

Iran's regional ranking in CO_2 emission (Agency, 2022)

This research analyzes the fairness arguments presented in 168 nationally determined contributions submitted under the 2015 Paris Agreement, evaluating their alignment with established principles of international environmental law. The findings indicate that while many NDCs base their fair share assessments on globally accepted principles—such as sustainable development, common but differentiated responsibilities, equity, and special circumstances—others rely on indicators not grounded in these legal frameworks (Rajamani et al., 2021).

3.5. Theoretical foundations

This study is grounded in two key frameworks: integrated assessment modeling and cost–benefit analysis. IAMs, such as the DICE model, synthesize knowledge from economics, climate science, and policy analysis to evaluate the impacts of climate change and assess potential mitigation strategies.
As noted by Weyant et al. (n.d.), integrated assessment models function as practical frameworks for integrating insights from diverse disciplines. The following section provides a list of some of the most widely used models:

Table 1

Widely used in models for climate change analyses (other researches with mentioned references)

Model Name	Key Features/Strengths	Limitations	Suitable for Underdeveloped Countries	Reference
DICE/ RICE	Simplicity; global and regional focus (RICE); economic-cost analysis.	Limited sector-specific details; relies on high-level aggregated data.	Partially suitable; may lack the sectoral depth required for local policy-making.	(Kaufmann, 1997)
GCAM	Integration of energy, economy, water, and land use; detailed scenario analysis.	Complex to implement and requires significant data.	Well-suited for regional evaluations when adequate data is available.	(Calvin et al., 2019)
IMAGE	High effectiveness for analyzing global environmental changes and producing long-term projections.	High complexity and data-intensive.	Suitable where technical expertise exists; offers detailed environmental impact analysis.	(Alcamo et al., 1994)

Model Name	Key Features/Strengths	Limitations	Suitable for Underdeveloped Countries	Reference
REMIND	Focus on energy systems, macroeconomic growth, and investment pathways.	Strong emphasis on technological change; requires high expertise.	Useful for analyzing investment impacts, but often too complex for low-resource settings.	(Ueckerdt et al., 2017)
MESSAGE	Energy system optimization; adaptable for various energy strategies.	Requires specialized expertise; limited integration of social policies.	Beneficial for energy policy development if data is accessible.	(Pfenninger et al., 2014)
MERGE	Balance of economic growth with GHG reduction; regional differentiation.	Less detailed on technology-specific policies.	Suitable for economic analysis of climate policies, but may lack granular local data.	(Manne et al., 1995)
WITCH	Consideration of R&D, technology, and economic-energy-climate interactions.	High data and technical requirements; complex setup.	Good for technology-driven growth strategies, but requires substantial support.	(Goddéris et al., 2006)
AIM	Regional focus, particularly on the Asia-Pacific; flexible structure.	Primarily regional, limiting global applicability.	Suitable if regional data aligns; can be adapted for developing nations.	(Matsuoka et al., 2001)
TIAM	Focus on energy systems; adaptable for designing long-term, low-carbon strategies.	Data-intensive and requires specialized training.	Effective for energy sector planning when local data is utilized properly.	(Loulou et al., 2007)

Meanwhile, cost–benefit analysis provides a systematic approach for comparing the costs and benefits of various policy options, aiding decision-makers in prioritizing interventions that maximize societal welfare. Together, these frameworks form the analytical backbone of this research, enabling a robust, evidence-based assessment of Iran's emission reduction strategies.

4. Research methodology

Given the global trend toward defining national and individual responsibilities for GHG emission reduction, countries like Iran—which have high emission rankings yet face internal challenges such as limited experience, infrastructure, and proven mitigation policies—must develop strategies that reflect their actual circumstances. A quantitative approach is essential to this strategy-making process, enabling forecasts and expected outcomes to be shaped around environmental and emissions targets. Integrated assessment models are the primary tools used for this type of modeling and analysis.

This study employs the dynamic integrated climate and economy model, developed by William Nordhaus (1994), as a core tool for cost-benefit analysis. DICE is recognized as the first dynamic model to integrate a closed-loop system that connects economic activity, emissions, atmospheric concentrations, climate change impacts, and control strategies. It is particularly valuable for evaluating the costs and benefits of climate mitigation approaches and understanding the long-term consequences of various policies. While more advanced models like GCAM offer sector-specific insights, their complexity exceeds Iran's current analytical capacity. DICE provides a foundational and widely utilized framework that is applied by governments to calculate the social cost of carbon, develop consistent scenarios, and assess policy uncertainties.

To model CO_2 emissions in Iran, we evaluated several versions of the DICE model and selected the simplified DICE 2023 (S-DICE) for an initial analysis. This choice was driven by Iran's unique constraints, including economic sanctions, data gaps, and limited climate policy experience, which necessitate an accessible tool for policymakers unfamiliar with complex climate-economic modeling. The S-DICE model simulates the economic effects of climate change over a 50-year horizon, and MATLAB software was used to compile the model codes and generate outputs.

It is important to acknowledge the inaccuracies and limitations of the S-DICE and DICE models, which are documented in the literature. A brief summary of these limitations and suggested solutions is provided in the following section. Despite the incompleteness and defects, the simplified DICE model was selected as a suitable starting point. Future research can build on this foundation by applying the full DICE 2023 model or combining DICE with other models, incorporating more sectoral and regional input data to yield further results and enable comparative analysis.

5. Findings and discussions

Several scenarios were designed to monitor the effects of different mitigation models on GDP, temperature, and CO_2 emissions, based on the following variables and policy approaches.

Table 1

SDICE model input variables for Iran (authors' calculations based on simplified DICE model output)

Simplified DICE Parameters	Variable Data	Reference
1. GDP0: Initial GDP for Iran	434 billion USD	(IMF, World Economic Outlook 2023)
2. g: Initial annual GDP growth rate	0.03	(IMF, World Economic Outlook 2023)
3. T0: Initial temperature in Celsius (annual country average)	20 degrees for 2024	(Iranian Meteorological Organization, n.d.)
4. E_Growth: Initial annual emission growth rate	0.02	(International Energy Agency., n.d.)
5. E0: Annual carbon emissions in million tons	696	(International Energy Agency., n.d.)
6. Carbon_Price: Price per ton of CO_2	10 USD	Primary assumption
7. Investment Rate: Percentage of GDP allocated to mitigation	0.02	Primary assumption
8. Climate_sensitivity: Temperature increase against doubling CO	0.01	Primary assumption
9. Damage_coefficient: The parameter used to calculate the economic damage from temperature increases, based on Nordhaus's research, indicates that a 3°C temperature rise in the DICE model is associated with an approximately 2% reduction in economic output, or gross domestic product (W. D. Nordhaus, 2017).	0.0002	(W. D. Nordhaus, 2017)
10. Years: Period of analysis in years	50	Primary assumption

The MATLAB code was executed, and the scenarios were run. The resulting outputs are presented below.

5.1. A List of scenarios and projected outputs are as below

1. Business as Usual (BAU) Scenario: No new policies are applied, and the economy continues to operate as usual.

Results:

- CO_2 emissions and GDP grow at a fixed, projected rate.
- Temperature and economic damage increase.

2. Carbon Pricing Scenario: A carbon tax is applied at a rate of $10 per ton of CO_2.

Results:

- CO_2 emissions are gradually reduced.
- GDP experiences a short-term decrease due to the carbon tax.
- Temperature and economic damage are lower than in the BAU scenario.

3. Renewables Scenario: Investment in renewable energy is set at 1% of GDP.

Results:

- CO_2 emissions are significantly reduced, while GDP growth experiences a slight increase.
- Temperature and economic damage decrease substantially.

4. Efficiency Scenario: Implements measures to increase energy efficiency in industries and buildings.

Results:

- CO_2 emissions decrease while GDP grows.
- Temperature and economic damage are reduced.

Based on the results from these scenarios, the following charts illustrate how each output variable changes over time under each policy framework.

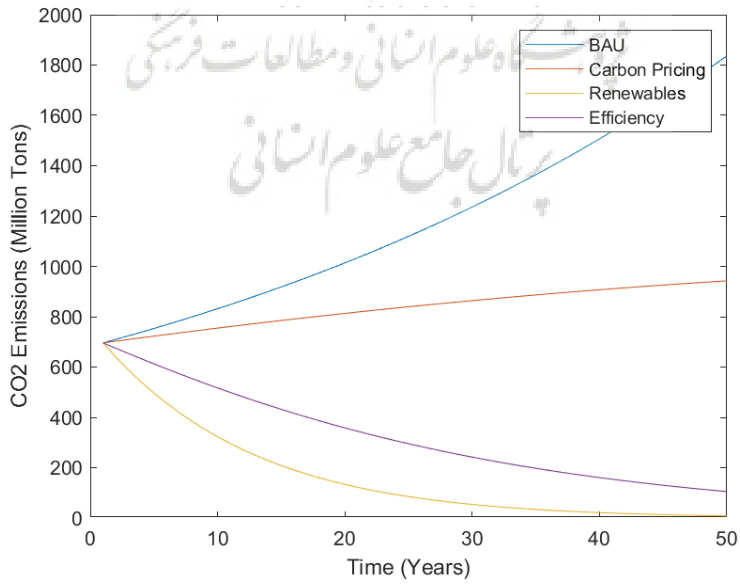

Figure 5

CO_2 emission over time (authors' calculations based on simplified DICE model outputs)

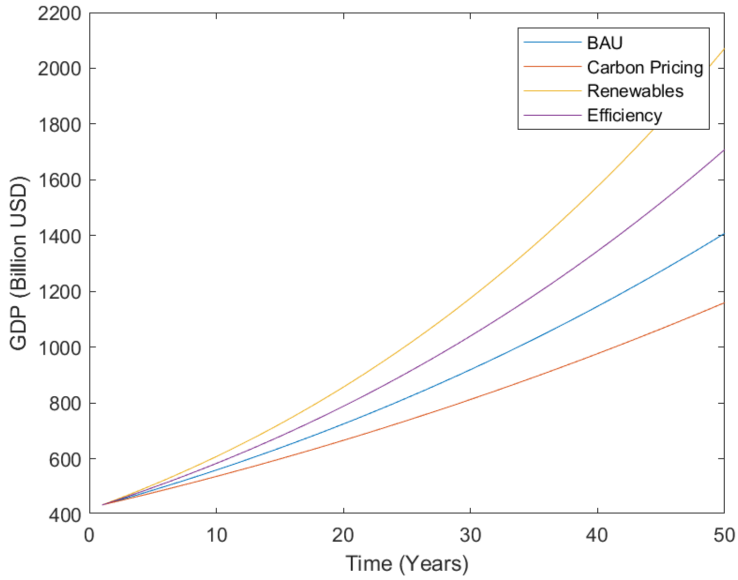

Figure 6

GDP over time (authors' calculations based on simplified DICE model outputs)

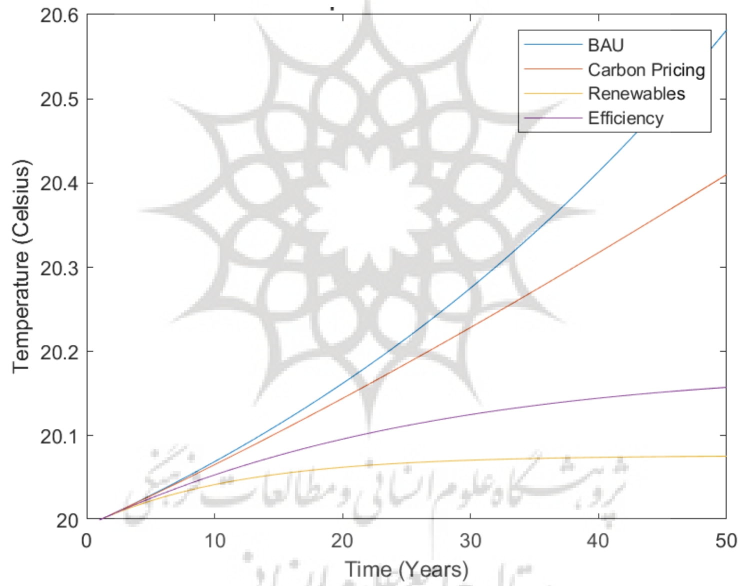

Figure 7

Temperature over time (authors' calculations based on simplified DICE model outputs)

5.2. Sensitivity analysis of key parameters and inputs

To evaluate the model's robustness and identify the most influential parameters, a sensitivity analysis was conducted. Four key input parameters were varied by ±50% from their baseline values, and their impact on Gross Domestic Product (GDP) and the increase in CO_2 emissions was analyzed at 10-year intervals over a 50-year period.

The parameters examined were:

1. GDP Growth Rate
2. Annual CO_2 Emission Growth Rate

3. Carbon Price per Ton
4. Damage Coefficient Due to Temperature Increase

Analysis of Sensitivity Results

1. GDP Growth Rate

- **Increase (+50%):** Leads to exponential GDP growth and a rise in CO_2 emissions due to heightened economic activity.
- **Decrease (–50%):** Significantly restricts GDP growth but also reduces CO_2 emissions.
- **Conclusion:** The GDP growth rate is a primary driver of both economic output and environmental impact.

2. CO_2 Emission Growth Rate

- **Increase (+50%):** Causes a surge in atmospheric CO_2 levels and a long-term decline in GDP due to amplified climate-related damages.
- **Decrease (–50%):** Effectively controls CO_2 emissions and improves long-term GDP performance.
- **Conclusion:** This parameter is critical for achieving climate objectives and maintaining economic health.

3. Carbon Price

- **Increase (+50%):** Reduces CO_2 emissions by up to 70% but exerts short-term downward pressure on GDP.
- **Decrease (–50%):** Leads to a rapid increase in CO_2 emissions and provides a temporary boost to GDP.
- **Conclusion:** Carbon pricing is a powerful tool for emission reduction, though its economic costs necessitate complementary support measures.

4. Damage Coefficient

- **Increase (+50%):** Decreases GDP due to higher climate-related economic costs, with minimal direct impact on CO_2 emission levels.
- **Decrease (–50%):** Improves GDP by reducing climate damage costs, while CO_2 emissions remain nearly constant.
- **Conclusion:** This parameter predominantly affects economic outcomes rather than directly influencing environmental metrics.

Final Summary

The successful application of the simplified DICE model in this study supports our hypothesis that it can serve as a foundational tool for designing initial emission reduction policies in Iran, despite its inherent limitations.

High-Risk Parameters

- The **CO_2 emission growth rate** and **carbon price** have the most significant impact on CO_2 emission trajectories.
- The **GDP growth rate** and **damage coefficient** have the most substantial effect on GDP outcomes.

The results of the sensitivity analysis are summarized in the tables below.

Table 3

Impact of variables on GDP (in billion dollars)

Variable	Change	Year 10	Year 20	Year 30	Year 40	Year 50
GDP Growth	+50%	652	920	1,305	1,842	2,601
	–50%	217	306	434	614	867
e_growth (0.02)	+50%	410	560	765	1,042	1,418
	–50%	460	645	905	1,270	1,782
carbon_price (10)	+50%	420	580	800	1,100	1,512
	–50%	448	630	885	1,245	1,750
investment_rate (0.02)	+50%	430	605	850	1,195	1,680
	–50%	438	615	865	1,215	1,710

Table 4

Impact of variables on co_2 emission (in million tons)

Variable	Change	Year 10	Year 20	Year 30	Year 40	Year 50
GDP Growth	+50%	1,044	1,276	1,560	1,907	2,331
	–50%	522	638	780	953	1,165
e_growth (0.02)	+50%	1,530	2,340	3,580	5,480	8,390
	–50%	870	760	660	580	510
carbon_price (10)	+50%	696	522	391	293	220
	–50%	1,044	1,566	2,349	3,523	5,285
investment_rate (0.02)	+50%	696	626	563	507	456
	–50%	696	783	881	991	1,115

5.3. Limitations and uncertainties

This study employs conservative estimates in its parameters due to current data scarcity. Future research will explore the sensitivity of the results by testing a wider range of assumptions, particularly regarding variables like GDP growth rates.

5.4. Implications of Inaccuracies in model or input data

While the simplified DICE model provides a valuable starting point for formulating emission control policies in Iran, it is crucial to acknowledge its inherent limitations. Iran's unique challenges—including data gaps, economic sanctions, and limited climate policy experience—mean the model may not fully capture the nation's socio-economic and environmental complexities. If unaddressed, these limitations could lead to suboptimal or misguided policy decisions.

For instance, the model's reliance on consistent and accurate data may not align with Iran's reality, potentially causing misestimation of the costs and benefits of various mitigation strategies. Errors in forecasting GDP growth, CO_2 emissions, or temperature increases could steer policymakers toward ineffective measures with adverse economic or environmental consequences.

To mitigate these risks, future studies should adopt the following steps:

1. **Use Multiple Models:** Policymakers should employ a combination of integrated assessment models to cross-validate results and build a more robust understanding of potential outcomes.
2. **Improve Data Collection:** Systematic efforts to collect higher-quality, granular, sectoral data are essential for improving the reliability of model inputs and outputs.
3. **Expand Sensitivity Analysis:** Conducting thorough sensitivity analyses for each model and policy change can identify the most influential variables, allowing decision-makers to prioritize critical factors in policy design.

By proactively addressing the model's limitations, Iranian policymakers can develop more resilient and effective emission reduction strategies. This approach will help manage the uncertainties inherent in modeling and ensure that policies are both realistic and impactful.

6. Conclusions

The primary objective of this research was to establish the first climate model-based strategy for Iran's CO_2 emissions, with a framework designed to be expandable to all greenhouse gases. A significant limitation was data scarcity, caused by both a general lack of clarity in economic and emissions data and insufficient sectoral information—some of which is related to sanctions, and some of which is not. To facilitate a practical starting point, we employed the simplified DICE model with fundamental economic calculations. This approach allowed us to focus on developing a foundational strategy and analysis, providing decision-makers with an initial, rule-of-thumb policy framework. The successful application of the simplified DICE model in this study confirms our hypothesis that it can serve as a foundational tool for designing initial emission reduction policies in Iran, despite its limitations.

For future research, we suggest designing and analyzing various target-based scenarios, such as meeting Paris Agreement obligations of a 4% CO_2 cut over 30 years or achieving specific temperature reduction targets. To enhance accuracy, all economic parameters should be recalibrated with greater precision. Subsequent studies could employ more sophisticated models or a hybrid modeling approach, incorporating precise feedback from implemented strategies to improve policy efficacy. Furthermore, the impact of individual or collective GHGs could be calculated to inform targeted, sectoral emission policies. This research demonstrates the positive impact of carbon pricing, investment in renewables, and energy efficiency measures on GDP, temperature stabilization, and CO_2 emission reduction.

Nomenclature

CBA	Cost–benefit analysis
DICE	Dynamic integrated climate and economy
GDP	Gross domestic product
GHGs	Greenhouse gases
IAMs	Integrated assessment models
NAMAs	Appropriate mitigation actions
NDCs	Nationally determined contributions
PCT	Personal carbon trading
REDD+	Deforestation and forest degradation

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