



# DEVELOPING A CONCEPTUAL MODEL FOR RECIPROCAL IMPACTS BETWEEN CLIMATE CHANGE AND ENERGY SECURITY IN THE MEDITERRANEAN REGION

Zineb Znagui

Independent Researcher

## Abstract

Climate change and energy security represent interdependent challenges of vital importance, particularly in the Mediterranean region. Rising temperatures, extreme weather events and changing precipitation patterns threaten the sustainability of energy sources. At the same time, the energy sector, vital for economic growth, contributes to the carbon footprint of the region. Understanding the interplay between these challenges is important, since the energy sector contributes significantly to global emissions while climate change threatens energy security. This policy brief explores the reciprocal impacts between climate change and energy security in the Mediterranean, emphasising the need for collaborative and innovative approaches. By providing a conceptual framework tailored to policy-makers and stakeholders, this paper aims to foster a deeper understanding and concurrent management of these complex issues in the region.

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## Introduction

Climate change and energy security are both considered to be among the most critical challenges of our time, presenting profound challenges on a global scale, and particularly in the Mediterranean region. Although being often considered as separate challenges, their causes and consequences are closely interconnected (Toke & Vezirgiannidou, 2013; Eshun et al., 2024). In this respect, the World Meteorological Organization (WMO) reported that climate change is threatening energy security while, at the same time, the energy sector is considered as the source of around three-quarters of global greenhouse gas emissions (WMO, 2024).

As the Mediterranean faces the escalating challenges posed by climate change, characterised by rising temperatures, increasing greenhouse gas emissions and the growing frequency of extreme weather events, the link with energy security becomes ever more marked (Cevik, 2022). Conversely, energy security considerations – encompassing renewable energy capacity, infrastructure resilience, accessibility, affordability, and market dynamics – profoundly influence the vulnerability and resilience of the Mediterranean region to climate-induced disruptions (Flouros, 2022). Understanding the intricate interplay between climate change and energy security is essential for effective policy formulation and strategic planning.

Accordingly, addressing the interconnected challenges of climate change and energy security in the Mediterranean region requires collaborative and innovative approaches transforming abstract concepts into easy-to-understand information to policy-makers, businesses and communities. For instance, the development of comprehensive conceptual frameworks may provide a more holistic approach to handle these critical challenges. This policy brief seeks to unveil the reciprocal impacts between climate change and energy security in the Mediterranean region via a quantifiable framework addressed to policy-makers and stakeholders. Through this approach, the paper aims to highlight and synthesise the existing literature on the intricate challenges at the nexus of climate change and energy security in the Mediterranean.

## Climate change implications and energy security challenges in the Mediterranean

The Mediterranean region, characterised by the diversity of its ecosystems and the complexity of its geopolitics, is facing challenges linked to the damaging effects of climate change and concerns of energy security (Lange, 2019; IPCC, 2023).

The Intergovernmental Panel on Climate Change (IPCC) has revealed that the Mediterranean region remains one of the most vulnerable areas to climate change on the globe (Moatti & Thiébault, 2018a). At present, the Mediterranean is experiencing severe drought conditions, affecting the availability of water resources and aggravating the alarming situation that persists in North Africa for six years (Toreti et al., 2024). Among the factors contributing to this situation are above-average temperatures, with a series of non-seasonal high temperature. While the global average air temperature is now about 1.1°C above pre-industrial values, the Mediterranean region is approaching 1.54°C (Papadopoulos et al., 2024).

Furthermore, the Mediterranean basin collectively contributes a significant share of global greenhouse gas emissions, accentuating the ongoing situation of global warming and climate change (Cramer et al., 2018). This elevated level of emissions further exacerbates the vulnerability of the region, which has been illustrated by the extreme weather events experienced by Mediterranean countries over the past year. From

devastating floods in Libya to unprecedented wildfires in Greece and North Africa, these events are symptomatic of the rapid deterioration of the climate in the region.

On the other hand, the imperatives of energy security in the Mediterranean are leading to a complex situation described as combining rapid growth in energy demand and economic growth with low energy efficiency (Grigoriadis & Çetin, 2024). Forecasts predict a significant gap between energy demand and supply in the coming decades in the Southern Mediterranean (Drobinski et al., 2020; Agoundedemba et al., 2023). Current trends will likely lead to a 37% increase in the overall energy demand in the Mediterranean region by 2050 (OME, 2021). Meeting the growing demand for energy requires considerable investment in infrastructure. However, the Mediterranean countries are confronted with the challenge of improving and expanding energy production, transmission and distribution systems, as well as the complexity of financing them, particularly for disadvantaged communities. As a result, the Mediterranean energy landscape reflects a paradoxical state of inequality, juxtaposing unparalleled opportunities for energy security and cooperation with the reality of costly physical infrastructure (Vardakastanis & De Felipe Lehtonen, 2023).

Furthermore, the energy security in the region is influenced by the current geopolitical tensions, namely the ongoing Russian invasion of Ukraine as well as the Gaza war. In consequence to geopolitical turbulence, an international energy crisis has emerged. While some Mediterranean countries are affected by the increase in energy costs, mainly due to their dependence on energy imports, such as Greece, Italy, and Morocco, other countries like Algeria are benefiting from an increase in demand for their energy exports, particularly to Europe, which is seeking alternatives to Russian sources (Ertl & Zegzouti, 2023). These new opportunities encourage exporting countries to continue expanding their energy production and, consequently, strengthen their landscape in terms of energy security.

However, the Mediterranean region lies at the nexus of growing vulnerability to climate change and complex energy security challenges. With its distinctive climatic characteristics and complex energy landscape, it is vital to understand the reciprocal impacts of climate change and energy security in this region. Rising temperatures, extreme weather events and changing precipitation patterns are threatening the reliability and sustainability of energy sources. At the same time, the energy sector, vital for economic growth, contributes to the carbon footprint of the region, worsening the effects of climate change.

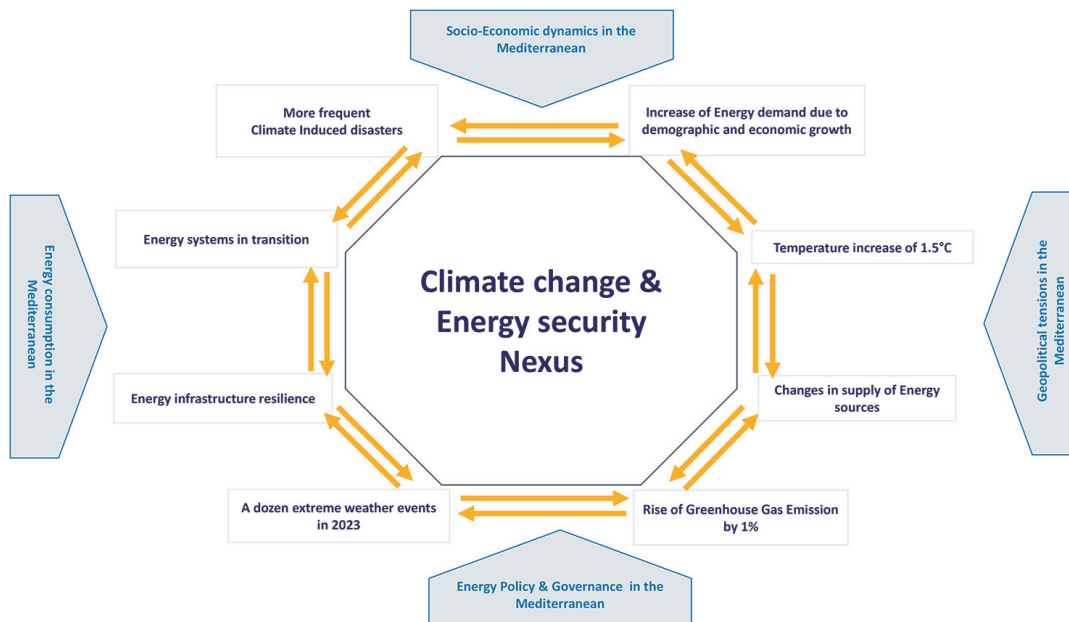
## **Conceptual framework of the reciprocal impacts between climate change and energy security in the Mediterranean region**

The climate system and energy landscape operate as non-linear dynamic systems whose components influence each other (Noto et al., 2023). The existing studies lack conceptualisation that elucidates the complex relationships and dynamics. It is therefore necessary to develop a comprehensive framework highlighting the nuanced interplay between climate change and energy security, while considering the context variables relating to the Mediterranean region.

The following figure (Figure 1) presents a proposition for a conceptual framework that illustrates reciprocal impacts between climate change and energy security in the Mediterranean region. In this respect, the framework organises factors into a coherent structure, helping to clarify their interconnections, which is essential for developing effective strategies to mitigate climate change while ensuring energy security. It encourages a holistic approach considering reciprocal impacts, which is essential for developing comprehensive

solutions that simultaneously address both challenges. To construct this model, a systematic review of existing literature, regional reports and policy documents was considered.

**Figure 1.** Framework of the reciprocal impacts between climate change and energy security in the Mediterranean region. Source: Compiled by the author



Examining the complex dynamics between climate change and energy security in the Mediterranean region requires an in-depth consideration focused on four main aspects. Firstly, there is the concern about changes in energy demand due to rising temperature in the Mediterranean. In this situation, existing energy infrastructures and networks are under pressure from increased cooling demand during warmer periods, which can lead to power shortages or blackouts (Georgopoulou et al., 2024). This pressure can be exacerbated by obsolete or insufficient infrastructure, affecting the ability of the region to meet spikes in energy demand. In addition, increased use of air-conditioning and cooling systems can lead to higher energy consumption, resulting in higher costs for consumers and businesses alike (Pérez-Andreu et al., 2018). Rising energy consumption not only increases operational expenses, but also exacerbates a key aspect of energy security: ensuring that energy remains affordable for end users. As defined by the International Energy Agency (IEA), energy security entails the uninterrupted availability of energy sources at an affordable price (IEA, 2014). Furthermore, rising energy demand could contribute to increased greenhouse gas emissions, exacerbating climate change and perpetuating the cycle of rising temperatures.

Secondly, the energy-related greenhouse gas emissions in the region emerge as crucial determinant in navigating the energy landscape of the region. Indeed, the emissions have a profound influence on environmental sustainability and climate change mitigation initiatives. As the Mediterranean region faces the challenge of reducing emissions and converting to cleaner energy sources, understanding the dynamics and impact of these greenhouse gases becomes crucial. Policies, investments and technological innovations aimed at reducing

emissions are essential to mapping out a sustainable energy future for the region, offering not only environmental benefits but also opportunities for economic growth, energy security and societal well-being (Bartoletto, 2021). Therefore, prioritising initiatives to reduce energy-related greenhouse gas emissions is the foundation for shifting the energy landscape towards a more sustainable and resilient future of the Mediterranean region.

Thirdly, vulnerability of energy infrastructure due to extreme weather events in the Mediterranean region is a major challenge that requires immediate attention. As the frequency and intensity of extreme weather events such as storms, heat waves and droughts increase in the region due to climate change, energy systems are facing greater risks of disruption (Gonçalves et al., 2024). Coastal power plants, offshore wind farms and pipelines are particularly susceptible to damage from hurricanes and storm surges, while prolonged heat waves strain power grids and threaten energy supplies. In addition, water shortages resulting from droughts threaten hydroelectric power generation and the cooling processes of thermal power plants (Varianou et al., 2017). Addressing these vulnerabilities requires comprehensive strategies that integrate climate resilience into energy infrastructure planning, invest in robust infrastructure designs, deploy advanced monitoring and early warning systems, and promote renewable energy sources that are more resilient to extreme weather conditions.

Finally, the impact of climate-induced disasters on energy systems in the Mediterranean represents another side of reciprocal impacts between climate change and energy security in the region. From the increasing frequency of extreme weather events to prolonged droughts and heat waves, Mediterranean energy networks are facing unprecedented challenges. These disasters not only directly damage energy infrastructures but also disrupt supply chains, hampering the distribution of essential resources such as electricity and fuel. In addition, rising sea levels threaten coastal power plants and transmission lines, further complicating the reliability of energy supplies (Moatti & Thiébault, 2018b). In the face of escalating climate disasters, urgent action is needed to strengthen energy systems through resilience measures that help the region to recover from future climate shocks.

By addressing these four key dimensions, it is possible to achieve a balanced understanding of the reciprocal impacts between climate change and energy security, clearing the way for informed policy decisions and collaborative initiatives to maintain the environmental integrity and energy stability of the Mediterranean region.

## **Policy recommendations to strengthen climate change resilience and energy security sustainability in the Mediterranean region**

- The research findings underline the critical need for targeted and adaptive policy interventions to address the reciprocal impacts between climate change and energy security in the Mediterranean region. Policy-makers must navigate a complex landscape influenced by climatic variations, socioeconomic dynamics and energy infrastructure vulnerabilities. The following policy implications emerge from the analysis, providing a roadmap for sustainable development and building resilience in response to evolving challenges.
- An integrated approach to planning climate-resilient renewable energy infrastructures. Comprehensive strategies are required to address the growing threat of climate-related disasters in the Mediterranean. Initially, policy-makers must prioritise the development of climate-resilient energy infrastructures, incorporating adaptation measures to mitigate



the effects of extreme weather events. This involves rigorous infrastructure standards, reinforced coastal defences and strategic placement of energy facilities to minimise vulnerability. At the same time, it is vital to promote renewable energy sources vigorously. This means fostering and accelerating the adoption of renewable energies through favourable regulatory frameworks, such as the Renewable Energy Directive (RED II) and the Mediterranean Solar Plan, to accelerate the adoption of renewables. By combining these efforts, the Mediterranean region can not only strengthen its energy systems against climate-related disasters, but also lead the transition to a diversified and sustainable energy landscape, ensuring resilience and vitality in the face of environmental challenges.

- Strengthening adaptive governance and regulatory frameworks through socioeconomic integration. To overcome the multifaceted challenges of climate change and ensure the resilience of energy systems, policy-makers need to adopt a holistic approach that integrates socioeconomic considerations and adaptive governance frameworks. Inclusive policies that acknowledge the diverse impacts of climate change on communities and prioritise investment in social resilience measures and job creation in renewable energy sectors are essential to mitigate disparities and promote social cohesion, such as the Mediterranean Strategy for Sustainable Development (MSSD) initiative, developed by the United Nations Environment Programme (UNEP). In addition, adaptable governance and regulatory frameworks are crucial, as they need to be flexible to adjust to changing climatic conditions and new energy landscapes. Building upon mechanisms established under the Mediterranean Integrated Coastal Zone Management (ICZM) Protocol and the Renewable Energy Directive, policy-makers should institute periodic reviews of policies, foster ongoing dialogue with stakeholders, and integrate scientific and technological advances into regulatory frameworks to enable proactive responses to evolving challenges. By adopting these integrated strategies, policy-makers can foster sustainable energy transitions while ensuring equitable outcomes for all communities in the face of climate-induced disruption.
- Promoting cross-border collaboration via investment in common infrastructure, innovation, research and knowledge sharing. Addressing the complex interplay between climate change and energy security in the Mediterranean region requires a multifaceted approach that integrates cross-border collaboration and investment in innovation and research. In recognition of the cross-border nature of these challenges, policy-makers should facilitate regional cooperation, knowledge sharing and joint initiatives between Mediterranean countries. By encouraging collaborative research projects, common infrastructure development and policy alignment, countries can collectively strengthen the resilience of the region's energy systems to climate-related disasters. At the same time, prioritising investment in innovation and research is essential to remain at the forefront of evolving challenges. By supporting cutting-edge technologies, adaptation strategies and interdisciplinary approaches through research initiatives, political decision-makers can have the evidence base they need to adopt effective policies. The creation of research clusters, the encouragement of private sector research and the promotion of collaboration between academia and industry will help to stimulate innovation and resilience in the Mediterranean region's energy landscape.

## Conclusion

As extreme weather events become more frequent, the Mediterranean region is facing increased vulnerabilities that intersect with its energy infrastructure and socioeconomic dynamics. This intersection creates a complex web of reciprocal impacts, requiring in-depth examination to unravel the complexities and propose insightful solutions. The challenge lies in the complex interplay between climate change and energy security, with one intensifying

the challenges presented by the other. Indeed, working to reduce climate change implications and to foster energy security imperatives should be improved simultaneously. It is also essential to understand the reciprocal impacts within this dynamic system in order to design effective strategies that ensure both climate resilience and energy security in the region.

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