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CURRENT TRENDS AND INSTITUTIONAL FRAMEWORKS IN CLIMATE CHANGE RESEARCH: A EUROPEAN AND NATIONAL PERSPECTIVE

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Abstract

Research on climate change has become a cornerstone of the global scientific and political response to one of the most pressing environmental crises. This paper provides an overview of major climate research directions, with a focus on international, European, and national institutional frameworks. Based on the analysis of strategic documents and institutional sources, the paper identifies key trends, structural gaps, and opportunities for advancing national climate research in Romania. It highlights the need for interdisciplinary approaches and stronger links between science and public policy as critical components of effective climate action.

Key words**:** *adaptation, climate change, climate research, mitigation, science-policy interface.*

INTRODUCTION

Climate change has evolved from an environmental concern to an emerging issue on global political, economic, and scientific agendas. The manifestations of climate instability, ranging from extreme weather events to shifts in precipitation patterns and rising sea levels, pose direct risks to biodiversity, public health, water availability, and infrastructure.

What distinguishes current climate dynamics from previous geological or meteorological shifts is the speed, scale, and underlying anthropogenic influence. A growing body of evidence confirms that human activities, particularly fossil fuel combustion, deforestation, and industrial agriculture, have drastically altered atmospheric composition, leading to global warming and associated feedback effects (IPCC, 2021; IPCC, 2022).

Since the late 20th century, climate science has matured as an interdisciplinary field, integrating atmospheric physics, oceanography, ecology, geography, and socio-economic analysis.

The European Union (EU) has played a significant role in coordinating climate research and funding programmes, which will be further detailed in subsequent sections.

Over the past two decades, scientific research has emerged as both a diagnostic and a prescriptive tool in addressing climate change. It not only deepens our understanding of physical and ecological systems but also informs the design of mitigation and adaptation strategies. As the climate crisis intersects with challenges such as urbanisation, food security, and energy transition, there is an increasing demand for interdisciplinary and problem-oriented approaches to climate research (Bai et al., 2016). This article contributes to the scientific dialogue by reviewing the current state of climate change research. It identifies dominant research directions, maps institutional ecosystems at global and European levels, and reflects on Romania's position within this broader context.

MATERIALS AND METHODS

This study adopts a qualitative research approach, based on documentary analysis and thematic synthesis. Primary sources include official reports from international organisations such as the Intergovernmental Panel on Climate Change (IPCC) (IPCC, 2021), the World Meteorological Organization (WMO) (WMO, 2023), the European Environment Agency (EEA) (EEA, 2025), and the European Commission (EC) (European Commission, 2020). These sources were selected based on four key criteria: (i) credibility and institutional authority, (ii) thematic relevance to climate science and policy, (iii) recency (2015–2024),

and (iv) open-access availability to ensure transparency and replicability.

To structure the analysis, a thematic framework was applied, comprising the following four axes:

1. institutional structure and governance – this axis explore the key actors involved in climate change research at the international, European, and national levels, as well as their mandates, coordination mechanisms, and roles in policy support;
2. major scientific trends and innovations – here, the focus is on the evolving directions of climate research, including technological innovation, modelling capacities, and interdisciplinary shifts;
3. science–policy integration – this axis investigates how scientific knowledge is used to inform climate legislation, adaptation planning, and multilevel governance;
4. regional and national disparities – the final axis assesses asymmetries in research infrastructure, funding availability, institutional capacities, and participation in transnational programmes.

The Romanian research context was examined through national policy strategies, websites of public research institutes, and academic literature (National Meteorological Administration; The Ministry of Research, Innovation and Digitalisation) and recent integrative approaches on local governance in climate strategy (Drăghici et al., 2024). Particular emphasis was placed on identifying structural gaps in funding, digital infrastructure, scientific collaboration, and stakeholder engagement. The data analysis process was descriptive-interpretive, aimed at identifying systemic patterns and practical recommendations.

While qualitative documentary analysis is an effective tool for mapping institutional and thematic trends, its limitations must also be acknowledged. The method does not allow for empirical testing of hypotheses or for generalisation of findings across all EU member states. Furthermore, the reliance on official publications may overlook grey literature or localised research initiatives not captured in mainstream data repositories. However, the method is justified by the study's exploratory and comparative objectives, and by the need to establish a foundational understanding of systemic structures in climate research.

RESULTS AND DISCUSSIONS

International climate change research is coordinated through established institutions with distinct but complementary mandates. The IPCC synthesises scientific literature and provides assessment reports that inform global climate policy (IPCC, 2021). The WMO ensures access to harmonised meteorological datasets, which are essential for modelling and forecasting (WMO, 2023). The UNEP facilitates knowledge transfer, particularly for low- and middle-income countries (UNEP, 2023). These organisations increasingly collaborate to align climate science with policy and capacity-building efforts, contributing to a more integrated global research ecosystem.

At the European level, climate research is supported through a combination of strategic frameworks, legislative instruments, and dedicated funding programmes aimed at fostering innovation, scientific collaboration, and evidence-based policymaking. The European Commission's Joint Research Centre and EEA produce decision-support tools, vulnerability indices, and thematic maps used by national authorities (European Commission, 2020; EEA, 2025).

Table 1 presents a selection of key international and European institutions involved in climate change research, highlighting their primary areas of focus and the roles they play in supporting scientific advancement, policy development, and global coordination efforts.

Thematic evolution in climate research reveals a broadening scope that transcends disciplinary boundaries. Early scientific efforts focused on climatology and atmospheric chemistry, but the current landscape includes socio-economic vulnerability, policy innovation, technological transitions, and public engagement. One area is impact assessment, which quantifies climate effects on agriculture, infrastructure, public health, and water security. The development of mitigation strategies, including renewable energy, and sustainable transport, is equally prominent. Research into adaptation measures has gained ground, especially regarding nature-based solutions, climate-resilient infrastructure, and community-based planning (IPBES and IPCC, 2021; Raymond et al., 2017).

Table 1. Key Climate Research Institutions

Institution	Main Focus	Role
Intergovernmental Panel on Climate Change	Assessment of climate science and policy recommendations	Provides scientific basis for international climate negotiations
World Meteorological Organization	Meteorological observations and climate monitoring	Coordinates global weather and climate data systems
United Nations Environment Programme	Environmental policy and sustainable development	Supports climate initiatives and policy in developing countries
European Environment Agency	Environmental indicators and data for EU policy	Publishes key reports on EU environmental status
Joint Research Centre	Scientific support for EU policies	Develops tools and models for EU policy design

Despite these advances, significant asymmetries persist across regions. Romania illustrates some of the structural challenges facing Eastern European countries in aligning with EU and global research frameworks. Although institutions like the National Meteorological Administration (ANM), the National Institute for Earth Physics (INCDFP), and several universities contribute to climate research, their efforts are often isolated and underfunded. Participation in European projects remains low, and the country lacks integrated databases and interdisciplinary networks. Scientific findings are seldom used in policymaking, and there is little institutional capacity to bridge the gap between research and decision-making (Sarkki et al., 2015).

Key challenges include weak coordination between ministries and research bodies, insufficient digital tools, lack of long-term funding, and limited incentives for interdisciplinary collaboration. Yet, Romania's integration into European research frameworks presents a significant opportunity for capacity building, especially if local research agendas are aligned with EU priorities.

To consolidate these observations, a SWOT analysis was developed to outline the key strengths, weaknesses, opportunities, and threats influencing Romania's climate research system. This strategic overview (Figure 1) highlights internal capabilities and limitations, as well as external drivers that may either support or constrain future development.

In order to synthesise the structural challenges and strategic potential of Romania's climate research system, a SWOT analysis was conducted (Figure 1). This structured approach highlights internal and external factors influencing the national research environment and supports the identification of priority areas for capacity development.

Among the strengths, Romania benefits from an increasing academic interest in climate-related themes, with several universities and research institutes such as ANM actively engaged in monitoring and scientific studies.

However, the analysis also identifies significant weaknesses. The national research landscape remains fragmented and underfunded, with minimal strategic coordination between relevant ministries, academic bodies, and public authorities. The lack of open-access, interoperable data infrastructures, such as climate risk maps or national research repositories, limits both the visibility and the applicability of scientific work in national decision-making.

On the opportunity side, Romania has the potential to improve its position by leveraging available European funding mechanisms, responding to growing political and societal awareness of climate risks, and investing in interdisciplinary collaboration and innovation (OECD, 2021). The ongoing push for green transition policies, resilience planning, and sustainable development can serve as entry points for strengthening institutional research frameworks.

Nevertheless, several threats persist. These include continued underinvestment in research and development, the emigration of qualified researchers, administrative complexity in accessing funding, and the limited use of scientific evidence in policymaking processes. If left unaddressed, these factors could deepen existing gaps between Romania and more research-intensive EU Member States.

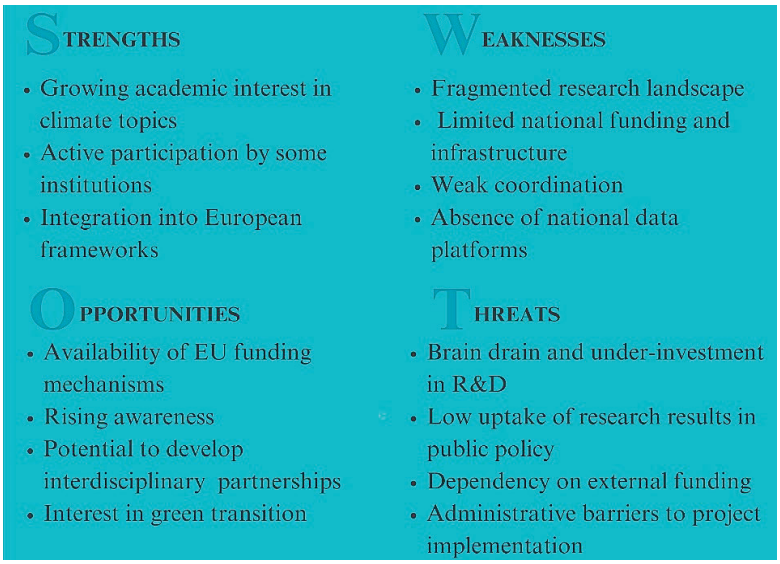

Figure 1. National-level capacity: SWOT Perspective on Romania's climate research landscape

This SWOT analysis reinforces the need for a national strategic vision that bridges science, policy, and practice, while supporting long-term investment in knowledge systems capable of responding to complex climate challenges.

Moreover, aligning Romania's research directions with foresight-based strategic planning is essential to strengthen institutional resilience and adaptive governance mechanisms. As highlighted by the European Commission's Strategic Foresight Report (European Commission, 2023), placing sustainability and wellbeing at the centre of strategic autonomy can help bridge the divide between knowledge production and societal needs. This implies not only more inclusive research agendas but also the mobilisation of innovation ecosystems around climate adaptation, mitigation, and environmental equity.

Recent studies underscore the importance of iterative, reflexive science-policy interfaces to support climate action in complex governance systems.

Sarkki et al. (2015) propose a dynamic framework that integrates credibility, relevance, legitimacy, and "iterativity" as dimensions that influence the effectiveness of science-based decision-making. Such frameworks could inspire improvements in Romania's institutional settings, particularly in strengthening the integration of scientific knowledge in local and national planning processes.

Additionally, climate science in Romania would benefit from adopting anticipatory and transdisciplinary methodologies. As Bai et al. (2016) argue, envisioning plausible and desirable futures in the Anthropocene requires transformative research agendas that go beyond problem identification and focus on systems innovation. This involves deeper collaboration between public authorities, academic institutions, and civil society, as already piloted in some local contexts.

Ultimately, strengthening Romania's position in the global climate research landscape requires both institutional transformation and alignment with forward-looking EU policy priorities.

Integrating foresight, innovation, and co-designed research can help Romania better generate and apply climate knowledge in support of public needs.

CONCLUSIONS

This article has outlined the evolving landscape of climate change research, with a particular focus on institutional structures, thematic directions, and regional disparities. Globally, the institutional architecture supporting climate science has matured through well-established organisations, as discussed earlier in the paper.

In Europe, the combination of policy instruments, dedicated research programmes, and technological platforms has fostered a dynamic research environment with increasingly integrated outputs.

Romania, however, continues to face structural challenges in aligning with this evolving framework.

As evidenced by the SWOT analysis, the national climate research ecosystem suffers from weak institutional coordination, inadequate funding, and a lack of digital infrastructure. Although several public research institutes have longstanding expertise, their efforts remain disconnected from policy processes and broader European initiatives.

Despite these weaknesses, Romania has the potential to strengthen its position through targeted reforms and strategic investments.

Opportunities include aligning national priorities with European foresight frameworks. Romania could also strengthen its participation in international research consortia and foster closer ties between academia, public institutions, and civil society. Lessons from countries with successful integration into EU research ecosystems could offer useful models for institutional reform.

Overall, strengthening climate resilience and adaptation capacities requires more than scientific output, it calls for coherent strategies that link research, governance, and innovation.

The insights presented here serve as a stepping stone for continued doctoral research and contribute to the broader understanding of how science can inform robust climate action, especially in structurally underrepresented regions like Romania.

Moreover, as climate research increasingly intersects with areas such as urban resilience, health, biodiversity, and digital innovation, the capacity to develop integrated, cross-sectoral responses becomes essential. Romania's future progress will depend not only on scientific excellence but also on the ability to embed research findings into operational decision-making, local planning, and national policy frameworks.

Finally, the institutional landscape must be supported by a long-term vision that promotes continuity, transparency, and collaboration. Establishing dedicated national programmes for climate knowledge co-production, incentivising open data sharing, and creating platforms for public-private partnerships can serve as catalysts for systemic change.

As climate risks intensify, the need for responsive, inclusive, and adaptive research systems will grow. This calls for a cultural shift in how research is prioritised, communicated, and leveraged, transforming climate science from an academic pursuit into a cornerstone of societal transformation.

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