Climate Vulnerability and Just Investment Strategies in Energy Transition Regions

Sofia Pavlidou[1], Despoina Kanteler[2], Ioannis Karagiannis[3], Panagiotis Pantazis[4], Lefteris Topaloglou[5,*] and Rafaella-Eleni Sotiropoulou[6]

[1] Department of Chemical Engineering, University of Western Macedonia, ZEP P.C. 50100, Kozani, Greece; s.pavlidou@uowm.gr

[2] Department of Chemical Engineering, University of Western Macedonia, ZEP P.C. 50100, Kozani, Greece; d.kanteler@uowm.gr

[3] Chemical Process and Energy Resources Institute / CERTH, 4th km Ptolemais-Mpodosakeio Hospital, Ptolemaida, Greece; dchemeng00033@uowm.gr

[4] Department of Planning and Regional Development, University of Thessaly, Pedion Areos, P.C. 38334, Volos, Greece; ppantaz@prd.uth.gr

[5] Department of Chemical Engineering, University of Western Macedonia, ZEP P.C. 50100, Kozani, Greece; etopaloglou@uowm.gr

[6] Department of Mechanical Engineering, University of Western Macedonia, ZEP P.C. 50100, Kozani, Greece; rsotiropoulou@uowm.gr

* Correspondence: etopaloglou@uowm.gr

Abstract
The process of energy transition necessitates that regions with a long-standing dependence on coal should develop simultaneously strategies that address the need for economic restructuring, social equity and environmental sustainability. This article explores the importance of integrating climate vulnerability data into strategies for economic transformation. The research focuses on three European regions that have traditionally shown high coal dependency, Western Macedonia in Greece, Silesia in Poland and Stara Zagora in Bulgaria. Specifically, the contribution of geospatial analysis to the development of investment decision support tools is explored through the literature review. The empirical research in the 3 reference regions involves questionnaires, interviews and focus groups among experts in the quadruple helix to examine optimal land use strategies in relation to promoting resilience and just transition. The findings aim to contribute to the discussion on regional development strategies for high carbon-dependent regions, emphasizing climate vulnerability, resilience, and sustainability (McCauley & Heffron, 2018; Sovacool, 2021).

Background: A key component of the European Green Deal is a strategy of decarbonisation, aligned with global climate neutrality targets (European Commission, 2000). This transition, however, is expected to bring severe social, economic and environmental consequences involving extensive workplace shifts, widespread economic restructuring and various environmental challenges (Caldecott et al., 2017).

Recent literature and policy documents highlight the importance of climate vulnerability assessment in regional planning. This is especially relevant for transition regions, where the link between climate vulnerability and nvestment strategies towards just transition, is of outmost importance. This contribution focuses on exploring the conditions and prerequisites for optimizing investment decisions towards supporting both the economic transformation and environmental sustainability of energy transition regions (Stevis & Felli, 2020).

Theoretical Framework: The research is grounded on the theories of just transition, sustainable development and regional resilience.

Just Transition Theory
Just transition theory focuses on the need for an inclusive and equitable shift advocating for strategies that support social inclusion and mitigate economic impacts in affected areas (Heffron & McCauley, 2018). This theory which was mainly developed by McCauley and Heffron (2018), further highlights the ethical and social dimensions of the energy transition towards a low- or zero-emission economy.

In particular, just transition theory explores policies that prevent economic exclusion, protect the rights of affected communiteis and ensure opportunities for new jobs in emerging sectors of the regional economy. This article attempts to integrate just transition principles by connecting them to investment strategies, aiming to minimise social and economic impacts in these post-coal regions (Newell & Mulvaney, 2013).

Sustainable Development and Climate Resilience
The theoretical discourse on sustainable development emphasises the environmental, social and economic aspects of strategies and policy decisions in line with sustainability principles (Sachs, 2015). The concept of sustainable development originally formulated by the Brutland Commission (1987) provides a framework for balancing economic growth, environmental protection and social justice. In transition regions in particular, the concept of sustainability is largely related to the concept of climate resilience which refers to the ability of a region to adapt against risks caused by climate change (Adger, 2000).

Building on the above framework, this article incorporates climate resilience theory into its analysis, explores the importance of geospatial analysis in assessing climate

vulnerability and examines the role of land use planning in sustainable economic development of transition regions (Füssel, 2007).

Regional Resilience and Adaptive Capacity
Theoretical analyses of regional resilience consider the capacity of carbon-dependent regions to adapt to evolving economic and social conditions as well as the connection between these developments and regional dispariteis (Carayannis et al., 2021).

Regional resilience theory focuses on exploring the adaptive capacity of communities and regions to respond adequately to environmental and economic challenges and drastic changes (Simmie & Martin, 2010). In this analysis, the concept of a region's adaptive capacity to restructure its economy and attract sustainable investment is central (Pike et al., 2010).

This research integrates empirical findings on regional resilience theory and assesses the importance of developing decision support tools that can make strategic investment planning of transition regions more effective.

Geospatial Analysis and Decision Support Systems
The development of geospatial analysis systems capable of incorporating climate vulnerability data, alongside the development of investment decision support tools, could meaningfully contribute to sustainable development planning in transition regions. The use of geospatial methodologies such as Geographic Information Systems (GIS) and remote sensing have proven to be very effective tools for assessing land use dynamics, environmental risks and investment evolution (Chen et al., 2019).

At the same time, Decision Support Systems (DSS) could contribute significantly to modelling investment scenarios, assessing economic, social and environmental impacts and optimally allocating available financial resources (Saaty, 2008). This paper analyses both geospatial approaches and Decision Support Systems to identify the most appropriate sectors and investment locations that are most aligned with the goals of regional resilience and equitable transition.

Empirical Methodology: The empirical research, focusing mainly on the assessment of climate vulnerability data in relation to investment strategies in three regions (Western Macedonia, Silesia, Stara Zagora) employs the following research methodologies:

- Questionnaires: Online questionnaires were distributed to experts frome the quadruble-helix (academia, business, policy, NGO) to assess dominant perceptions of climate vulnerability, investment strategy and fair energy transition (Creswell & Creswell, 2018).

- Interviews: Interviews were conducted with experts with deep knowledge on the issues of just energy transition, climate change and climate vulnerability (Bryman, 2016).
- Focus groups: interactive meetings were held with representatives of the quadrilateral helix to capture positions on land use and sustainable economic planning (Morgan, 1997).

Findings and Discussion: The empirical findings bring to the surface trends and challenges at the intersection of climate vulnerability and investment strategies.

<u>Western Macedonia (Greece):</u> Western Macedonia (Greece): The results of the survey revealed for Western Macedonia concerns over the slow pace of investments needed to diversify the dominant economic model. Climate vulnerability assessments indicated increased environmental risks, due to the huge land rehabilitation needs for former lignite mines that will cease to operate (Karakosta et al., 2019). Additionally, the lack of a stable investment strategy and favourable incentives has failed to commit investors to implement large-scale energy projects.

<u>Silesia (Poland):</u> The region's strong industrial tradition and the critical size of industrial activity has been key drivers in bringing about significant low-carbon investments. On the other hand, however, the need for better integration of climate vulnerability data into economic planning and its connection to regional resilience was highlighted (Wojnarowska, 2020). In addition, concerns were raised about reskilling strategies and its effectiveness in adressing labour market gaps aligning workforce skills with the new emerging sectors.

<u>Stara Zagora (Bulgaria):</u> Political instability due to continuous election cycles and a blurred regulatory framework have caused significant delays in investment. At the same time, climate risks associated with extensive mining activity remain substantial. Key stakeholders in the region highlighted the crucial role of participatory decision-making in strengthening public and community engagement to support transition policies (Dimitrova & Kazandjiev, 2022). Furthermore, the urgency of the need for sustainable and resilient land use planning in a way that favours the development of both renewable energy and the primary sector was underscored.

The research through the comparative analysis identified common challenges in all three regions summarised as follows. First, there is a shared for strengthened inclusiveness and participatory regional governance mechanisms. Second, for investment strategies to be viable, they must be integrated with sustainable and resilient land use planning. Third, access to climate data and climate vulnerability assessments utilizing geospatial analysis methods and their linkage to investment strategies is essential.

Successful cases of sustainable land use that take into account climate vulnerability data have shown that integrating climate risk assessments can lead to resilient and fair economic transitions (Newell & Mulvaney, 2013).

Conclusions: This article highlights the importance of integrating climate vulnerability data into the sustainable and resilient investment strategies of energy transition regions. In this context, decision-support tools with the underpinning of geospatial analysis and remote sensing methodologies could help to optimize investment decisions and enhance regional resilience. The effective implementation of this strategy, however, requires the strengthening of the place-based dimension of governance, inclusiveness and public engagement. Against this backdrop, future research should further explore how investment decision support tools will be able to incorporate real-time climate vulnerability data, supporting evidence-based policy making.

Extended Abstract References

Bryman, A. (2016). *Social Research Methods*. Oxford University Press.

Caldecott, B., Sartor, O., Spencer, T. (2017). *Lessons from previous coal transitions: High-level summary for decision-makers.* IDDRI.

Carayannis, E. G., Grigoroudis, E., Del Giudice, M. (2021). *Regional innovation and resilience: Theoretical foundations and empirical applications.* Springer.

Chen, W. Y., Su, Y. S., & Chou, C. L. (2019). *Geospatial technologies for climate change adaptation and sustainable development.* Environmental Research.

Creswell, J. W., & Creswell, J. D. (2018). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches.* SAGE.

Dimitrova, S., & Kazandjiev, V. (2022). *The challenges of energy transition in Bulgaria.* Energy Policy.

European Commission (2020). *The European Green Deal.*

Füssel, H. M. (2007). *Vulnerability: A generally applicable conceptual framework for climate change research.* Global Environmental Change.

Heffron, R. J., & McCauley, D. (2018). *What is the 'just transition'?.* Geoforum.

Karakosta, C., Doukas, H., & Psarras, J. (2019). *Energy transition challenges in Greece.* Energy Reports.

McCauley, D., & Heffron, R. (2018). *Just transition: Integrating climate, energy and environmental justice.* Energy Policy.

Meadowcroft, J. (2011). *Engaging with the politics of sustainability transitions.* Environmental Innovation and Societal Transitions.

Morgan, D. L. (1997). *Focus Groups as Qualitative Research.* SAGE.

Newell, P., & Mulvaney, D. (2013). *The political economy of the 'just transition'.* The Geographical Journal.

Sovacool, B. K. (2021). *Sustainable energy and climate mitigation strategies.* Renewable Energy.

Stevis, D., & Felli, R. (2020). *Global labor unions and just transition.* Global Environmental Politics.

Wojnarowska, A. (2020). *Economic restructuring in Silesia: Challenges and opportunities.* Regional Studies.